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## MARTINEAU AND MATERIALISM.[1]

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PRESENTED in the order of their publication, these Fragments will, I think, make it plain that, within the last two years, I have added no material iniquity to the list previously recorded against me. I have gone carefully over them all this year in Switzerland, bestowing special attention upon the one which has given most offense. To the judgment of thoughtful men I now commit them: the unthoughtful and the unfair will not read them, though they will continue to abuse them.

I have no desire to repay in kind the hard words already thrown at them and me; but a simple comparison will make clear to my more noisy and unreasonable assailants how I regard their position. To the nobler Bereans of the press and pulpit, who have honored me with their attention, I do not now refer. Webster defines a squatter as one who settles on new land without a title. This, in regard to anthropology and cosmogony, I hold to have been the position of the older theologians; and what their heated successors of to-day denounce as "a raid upon theology," is, in my opinion, a perfectly legal and equitable attempt to remove them from ground which they have no right to hold.

If the title exist, let it be produced. It is not the revision of the text of Genesis by accomplished scholars that the public so much need, as to be informed and convinced how far the text, polished or unpolished, has a claim upon the belief of intelligent persons. It is, I fear, a growing conviction that our ministers of religion, for the sake of peace, more or less sacrifice their sincerity in dealing with the cosmogony of the Old Testament. I notice this in conversation, and it is also appearing in print. Before me, for example, is a little *brochure*, in which a layman presses a clerical friend with a series of

[1] Preface to the forthcoming edition of "Fragments of Science."

questions regarding creation—the six-day period of divine activity, the destruction of the world by a flood, the building of an ark, the placing of creatures in it by pairs, and the descent from this ancestry of all living things, "men and women, birds and beasts." He asks his friend, "Do you, *without any mental reservation*, believe these things?" "If you *do*," he continues, "then I can only say that the accumulated and accepted knowledge of mankind, including the entire sciences of astronomy, geology, philology, and history, are [as far as you are concerned] naught and mistaken. If you do *not* believe those events to have so happened, or do so with some mental reservation, which destroys the whole sense and meaning of the narrative, *why do you not say so from your pulpits?*"

The friend merely parries and evades the question. According to Mr. Martineau, the clergy speak very differently indeed from their pulpits. After showing how the Mosaic picture of the genetic order of things has been not only altered but inverted by scientific research, he says: "Notwithstanding the deplorable condition to which the picture has been reduced, it is exhibited fresh every week to millions taught to believe it as divine." It cannot be said that error here does no practical harm, or that it does not act to the detriment of honest men. It was for openly avowing doubts which, it is said, others discreetly entertain, that the Bishop of Natal suffered persecution; it was for his public fidelity to scientific truth, as far as his lights extended, that he was branded, even during his recent visit to this country, as an "excommunicated heretic." The courage of Dean Stanley and of the Master of Balliol, in reference to this question, disarmed indignation, and caused the public to overlook a wrong which might not otherwise have been endured.

The liberal and intelligent portion of Christendom must, I take it, differentiate itself more and more, in word and act, from the fanatical, foolish, and more purely sacerdotal portion. Enlightened Roman Catholics are more specially bound to take action here; for the travesty of heaven and earth is grosser, and the attempt to impose it on the world is more serious, in their community than elsewhere. That they are more or less alive to this state of things, and that they show an increasing courage and independence in their demands for education, will be plain to the reader of the "Apology for the Belfast Address." The "Memorial" there referred to was the impatient protest of barristers, physicians, surgeons, solicitors, and scholars, among the Catholics themselves. They must not relax their pressure nor relinquish their demands. For their spiritual guides live so exclusively in the prescientific past, that even the really strong intellects among them are reduced to atrophy as regards scientific truth. Eyes they have, and see not; ears they have, and hear not; for both eyes and ears are taken possession of by the sights and sounds of another age. In relation to science, the ultramontane brain, through lack of

exercise, is virtually the undeveloped brain of the child. And thus it is that as children in scientific knowledge, but as potent wielders of spiritual power among the ignorant, they countenance and enforce practices sufficient to bring the blush of shame to the cheeks of the more intelligent among themselves.

Such is the force of early education, when maintained and perpetuated by the habits of subsequent life; such the ground of peril in allowing the schools of a nation to fall into ultramontane hands. Let any able Catholic student, fairly educated, and not yet cramped by sacerdotalism, get a real scientific grasp of the magnitude and organization of this universe. Let him sit under the immeasurable heavens, watch the stars in their courses, scan the mysterious nebulæ, and try to realize what it all is and means. Let him bring the thoughts and conceptions which thus enter his mind face to face with the notions of the genesis and ruin of things which pervade the writings of the princes of his Church, and he will see and feel what drivelers even men of strenuous intellect may become, through exclusively dwelling and dealing with theological chimeras.

But, quitting the more grotesque forms of the theological, I already see, or think I see, emerging from recent discussions, that wonderful plasticity of the theistic idea, which enables it to maintain, through many changes, its hold upon superior minds; and which, if it is to last, will eventually enable it to shape itself in accordance with scientific conditions. I notice this, for instance, in the philosophic sermon of Dr. Quarry, and more markedly still in that of Dr. Ryder. "There pervades," says the Rector of Donnybrook, "these atoms and that illimitable universe, that 'choir of heaven and furniture of earth,' which of such atoms is built up, a certain *force*, known in its most familiar form by the name of 'life,' *which may be regarded as the ultimate essence of matter.*" And, speaking of the awful search of the intellect for the infinite Creator, and of the grave difficulties which encompass the subject, the same writer says: "We know from our senses finite existences only. Now we cannot *logically* infer the existence of an infinite God from the greatest conceivable number of finite existences. There must always obviously be more in the conclusion than in the premises." Such language is new to the pulpit, but it will become less and less rare. It is not the poets and philosophers among our theologians—and in our day the philosopher who wanders beyond the strict boundary of Science is more or less merged in the poet—it is not these, who feel the life of religion, but the mechanics, who cling to its scaffolding, that are most anxious to tie the world down to the untenable conceptions of an uncultivated past.

Before me is another printed sermon of a different character from those just referred to. It is entitled "The Necessary Limits of Christian Evidences." Its author, Dr. Reichel, has been frequently referred to as an authority, particularly on personal subjects, during recent

discussions. The sermon was first preached in Belfast, and afterward, in an amplified and amended form, in the Exhibition Building in Dublin. In passing, I would make a single remark upon its opening paragraph. This contains an argument regarding Christ which I have frequently heard used in substance by good men, though never before with the grating emphasis here employed. "The resurrection of our Saviour," says Dr. Reichel, "is the central fact of Christianity. Without his resurrection, his birth and his death would have been alike unavailing: nay more, if he did not rise from the dead, his birth was the birth of a bastard, and his death the death of an impostor." This may be "orthodoxy;" but entertaining the notions that I do of Christ, and of his incomparable life upon the earth, if the momentary use of the term "blasphemy" were granted to me by my Christian brethren, I should feel inclined to employ it here.

Better instructed than he had been at Belfast, the orator in Dublin gave prominence to a personal argument which I have already noticed elsewhere. He has been followed in this particular by the Bishop of Meath and other estimable persons. This is to be regretted, because in dealing with these high themes the mind ought to be the seat of dignity—if possible of chivalry—but certainly not the seat of littleness. "I propose," says the preacher, "making some remarks on the doctrine thus propounded" [in Belfast]. "And, first, lest any of you should be unduly impressed by the mere authority of its propounder, as well as by the fluent grace with which he sets it forth, it is right that I should tell you, that these conclusions, though given out on an occasion which apparently stamped them with the general approbation of the scientific world, do not possess that approbation. The mind that arrived at them, and displayed them with so much complacency, is a mind trained in the school of mere experiment, not in the study, but in the laboratory. Accordingly, the highest mathematical intellects of the Association disclaim and repudiate the theories of its president. In the mathematical laws to which all material phenomena and substances are each year more distinctly perceived to be subordinated, they see another side of Nature, which has not impressed itself upon the mere experimentalist."[1]

In view of the new virtue here thrust upon the mathematician, D'Alembert and Laplace present a difficulty, and we are left without a clew to the peculiar orthodoxy of Prof. Clifford and other distinguished men. As regards my own mental training, inasmuch as my censors think it not beneath them to dwell upon a point so small, I may say that the foregoing statement is incorrect. The separation, moreover, of the "study" from the "laboratory" is not admissible,

[1] "Es ist ihre Taktik, die Gegner, gegen welche sie nichts sonst auszurichten vermögen, verächtlich zu behandeln, und allmählich in der Achtung des Publikums herabzusetzen." This was written of the Jesuits in reference to their treatment of Dr. Döllinger. It is true of others.

because the laboratory *is* a "study" in which symbols give place to natural facts. The word Mesopotamia is said to have a sacred unction for many minds, and possibly the title of my "Inaugural Dissertation" at Marburg may have an effect of this kind on my right reverend and reverend critics of the new mathematical school. Here accordingly it is: "Die Schraubenfläche mit geneigter Erzeugungslinie, und die Bedingungen des Gleichewichts auf solchen Schrauben." A little tenderness may, perhaps, flow toward me, after these words have made it known that I began my narrow scientific life less as an experimentalist than as a mathematician.

If, as asserted, "the highest mathematical intellects of the Association disclaim and repudiate the theories of its president," it would be their bounden duty to not rest content with this mere second-hand utterance. They ought to permit the light of life to stream upon us directly from themselves, instead of sending it through the polemoscope[1] of Dr. Reichel. But the point of importance to be impressed upon him, and upon those who may be tempted to follow him in his adventurous theories, is, that out of mathematics no salvation for theology can possibly come.

By such reflections I am brought face to face with an essay to which my attention has been directed by several estimable, and indeed eminent persons, as demanding serious consideration at my hands. I refer with pleasure to the complete accord subsisting between the Rev. James Martineau and myself on certain points of biblical cosmogony. "In so far," says Mr. Martineau, "as church belief is still committed to a given cosmogony and natural history of man, it lies open to scientific refutation." And again: "It turns out that with the sun and moon and stars, and in and on the earth, before and after the appearance of our race, quite other things have happened than those which the sacred cosmogony recites." Once more: "The whole history of the genesis of things Religion must surrender to the Sciences." Finally, still more emphatically: "In the investigation of the genetic order of things, Theology is an intruder, and must stand aside." This expresses, only in words of fuller pith, the views which I ventured to enunciate in Belfast. "The impregnable position of Science," I there say, "may be stated in a few words. We claim, and we shall wrest from Theology, the entire domain of cosmological theory." Thus Theology, so far as it is represented by Mr. Martineau, and Science, so far as I understand it, are in absolute harmony here.

But Mr. Martineau would have just reason to complain of me, if, by partial citation, I left my readers under the impression that the agreement between us is complete. At the opening of the eighty-ninth session of the Manchester New College, London, on October 6, 1874, Mr. Martineau delivered the Address from which I have quoted. It

[1] "An oblique perspective glass, for seeing objects not directly before the eyes."— *Webster.*

bears the title "Religion as affected by Modern Materialism;" and its references and general tone make evident the depth of its author's discontent with my previous deliverance at Belfast. I find it difficult to grapple with the exact grounds of this discontent. Indeed, logically considered, the impression left upon my mind by an essay of great æsthetic merit, containing many passages of exceeding beauty, and many sentiments which none but the pure in heart could utter as they are uttered here, is vague and unsatisfactory—the author appears at times so brave and liberal, at times so timid and captious, and at times so imperfectly informed regarding the position he assails.

At the outset of his address, Mr. Martineau states with some distinctness his "sources of religious faith." They are two—"the scrutiny of Nature" and "the interpretation of sacred books." It would have been a theme worthy of his intelligence to have deduced from these two sources his religion as it stands. But not another word is said about the "sacred books." Having swept with the besom of Science various "books" contemptuously away, he does not define the sacred residue; much less give us the reasons why he deems them sacred. His references to "Nature," on the other hand, are magnificent tirades against Nature, intended, apparently, to show the wholly abominable character of man's antecedents if the theory of evolution be true. Here, also, his mood lacks steadiness. While joyfully accepting, at one place, "the widening space, the deepening vistas of time, the detected marvels of physiological structure, and the rapid filling-in of the missing links in the chain of organic life," he falls, at another, into lamentation and mourning over the very theory which renders "organic life" a "chain." He claims the largest liberality for his sect, and avows its contempt for the dangers of possible discovery. But immediately afterward he damages the claim, and ruins all confidence in the avowal. He professes sympathy with modern science, and almost in the same breath he treats, or certainly will be understood to treat, the atomic theory, and the doctrine of the conservation of energy, as if they were a kind of scientific thimble-riggery.

His ardor, moreover, renders him inaccurate; causing him to see discord between scientific men, where nothing but harmony reigns. In his celebrated address to the Congress of German Naturforscher, delivered at Leipsic, three years ago, Du Bois-Reymond speaks thus: "What conceivable connection subsists between definite movements of definite atoms in my brain, on the one hand, and on the other hand such primordial, indefinable, undeniable facts as these: I feel pain or pleasure; I experience a sweet taste, or smell a rose, or hear an organ, or see something red? . . . It is absolutely and forever inconceivable that a number of carbon, hydrogen, nitrogen, and oxygen atoms, should be otherwise than indifferent as to their own position and motion, past, present, or future. It is utterly inconceivable how consciousness should result from their joint action."

This language, which was spoken in 1872, Mr. Martineau "freely" translates, and quotes against me. The act is due to a misapprehension of his own. Evidence is at hand to prove that I employed the same language twenty years ago. It is to be found in the *Saturday Review* for 1860; but a sufficient illustration of the agreement between my friend Du Bois-Reymond and myself is furnished by the discourse on "Scientific Materialism," delivered in 1868, then widely circulated, and reprinted here. With a little attention, Mr. Martineau would have seen that, in the very address his essay criticises, precisely the same position is maintained. "You cannot," I there say, "satisfy the human understanding in its demand for logical continuity between molecular processes and the phenomena of consciousness. This is a rock on which materialism must inevitably split whenever it pretends to be a complete philosophy of the human mind."

"The affluence of illustration," writes an able and sympathetic reviewer of this essay, in the *New York Tribune*, "in which Mr. Martineau delights often impairs the distinctness of his statements by diverting the attention of the reader from the essential points of his discussion to the beauty of his imagery, and thus diminishes their power of conviction." To the beauties here referred to I bear willing testimony; but the excesses touched upon reach far beyond the reader, to their primal seat and source in Mr. Martineau's own mind; mixing together *there* things that ought to be kept apart; producing vagueness where precision is the one thing needful; poetic fervor where we require judicial calm; and practical unfairness where the strictest justice ought to be, and I willingly believe is meant to be, observed.

In one of his nobler passages, Mr. Martineau tells us how the pupils of his college have been educated hitherto: "They have been trained under the assumptions—1. That the universe which includes us and folds us round is the life-dwelling of an Eternal Mind; 2. That the world of our abode is the scene of a moral government, incipient but not complete; and, 3. That the upper zones of human affection, above the clouds of self and passion, take us into the sphere of a Divine communion. Into this overarching scene it is that growing thought and enthusiasm have expanded to catch their light and fire."

Alpine summits must kindle above the mountaineer who reads these stirring words; I see their beauty and feel their life. Nay, in my own feeble way, at the close of one of the essays here printed, I thus affirm the "communion" which Mr. Martineau calls "Divine:" "'Two things,' said Immanuel Kant, 'fill me with awe—the starry heavens, and the sense of moral responsibility in man.' And in his hours of health and strength and sanity,[1] when the stroke of action

[1] In the first preface to the Belfast Address I referred to "hours of clearness and vigor" as four years previously I had referred to hours of "health and strength and

has ceased, and the pause of reflection has set in, the scientific investigator finds himself overshadowed by the same awe. Breaking contact with the hampering details of earth, it associates him with a power which gives fullness and tone to his existence, but which he can neither analyze nor comprehend."

Though "knowledge" is here disavowed, the "feelings" of Mr. Martineau and myself are, I think, very much alike. But, notwithstanding this mutual independence of religious feeling and objective knowledge thus demonstrated, he censures me—almost denounces me—for referring religion to the region of emotion. Surely he is inconsistent here. The foregoing words refer to an inward hue or temperature, rather than to an external object of thought. When I attempt to give the power which I see manifested in the universe an objective form, personal or otherwise, it slips away from me, declining all intellectual manipulation. I dare not, save poetically, use the pronoun "he" regarding it; I dare not call it a "mind;" I refuse to call it even "a cause." Its mystery overshadows me; but it remains a mystery, while the objective frames which my neighbors try to make it fit, simply distort and desecrate it.

It is otherwise with Mr. Martineau, and hence his discontent. He professes to *know* where I only claim to *feel*. He could make his contention good against me if he would transform, by a process of verification, the foregoing three assumptions into "objective knowledge." But he makes no attempt to do so. They remain assumptions from the beginning of his address to its end. And yet he frequently uses the word "unverified," as if it were fatal to the position on which its incidence falls. "The scrutiny of Nature" is one of his sources of "religious faith:" what logical foothold does that scrutiny furnish on which any one of the foregoing three assumptions could be planted? Nature, according to his picturing, is base and cruel: what is the inference to be drawn regarding its author? If Nature be "red in tooth and claw," who is responsible? On a mindless Nature, Mr. Martineau pours the full torrent of his gorgeous invective; but could the "assumption" of "an Eternal Mind"—even of a beneficent Eternal Mind—render the world objectively a whit less mean and ugly than it is? Not an iota. It is man's feelings, and not external phenomena, that are influenced by the assumption. It adds not a ray of light nor a strain of music to the objective sum of things. It does not touch the phenomena of physical Nature—storm, flood, or fire—nor diminish by a pang the bloody combats of the animal world. But it does add the glow of religious emotion to the human

sanity;" and brought down upon myself, in consequence, a considerable amount of ridicule. Why I know not. For I am still bound in honesty to confess that it is not when sleepy after a gluttonous meal, or suffering from dyspepsia, or even possessed by a physical problem demanding concentrated thought, that I care most for the "starry heavens, or the sense of responsibility in man."

soul, as represented by Mr. Martineau. Beyond this I defy him to go; and yet he rashly—it might be said petulantly—kicks away the only philosophic foundation on which it is possible for him to build his religion.

He twits incidentally the modern scientific interpretation of Nature because of its want of cheerfulness. "Let the new future," he says, "preach its own gospel and devise, if it can, the means of making the tidings *glad*." This is a common argument: "If you only knew the comfort of belief!" My reply to it is that I choose the nobler part of Emerson, when, after various disenchantments, he exclaimed, "I covet *truth!*" The gladness of true heroism visits the heart of him who is really competent to say this. Besides, "gladness" is an emotion, and Mr. Martineau theoretically scorns the emotional. I am not, however, acquainted with a writer who draws more largely upon this source, while mistaking it for something objective. "To reach the cause," he says, "there is no need to go into the past, as though being missed here he could be found there. But when once he has been apprehended by the proper organs of divine apprehension, the whole life of humanity is recognized as the scene of his agency." That Mr. Martineau should have lived so long, thought so much, and failed to recognize the entirely subjective character of this creed, is highly instructive. His "proper organs of divine apprehension"—denied, I may say, to some of the greatest intellects and noblest men in this and other ages—lie at the very core of his emotions.

In fact, it is when Mr. Martineau is most purely emotional that he scorns the emotions; and it is when he is most purely subjective, that he rejects subjectivity. He pays a just and liberal tribute to the character of John Stuart Mill. But in the light of Mill's philosophy, benevolence, honor, purity, having "shrunk into mere unaccredited subjective susceptibilities, have lost all support from Omniscient approval, and all presumable accordance with the reality of things." If Mr. Martineau had given them any inkling of the process by which he renders the "subjective susceptibilities" objective; or how he arrives at an objective ground of "Omniscient approval," gratitude from his pupils would have been his just meed. But as it is, he leaves them lost in an iridescent cloud of words, after exciting a desire which he is incompetent to appease.

"We are," he says, in another place, "forever shaping our representations of invisible things into forms of definite opinion, and throwing them to the front, as if they were the photographic equivalent of our real faith. It is a delusion which affects us all. Yet somehow the essence of our religion never finds its way into these frames of theory: as we put them together it slips away, and, if we turn to pursue it, still retreats behind; ever ready to work with the will, to unbind and sweeten the affections, and bathe the life with reverence, but refusing to be seen, or to pass from a divine hue of thinking into

a human pattern of thought." This is very beautiful, and mainly so because the man who utters it obviously brings it all out of the treasury of his own heart. But the "hue" and "pattern" here so finely spoken of are neither more nor less than that "emotion" and that "objective knowledge" which have drawn this suicidal fire from Mr. Martineau's battery.

I now come to one of the most serious portions of Mr. Martineau's pamphlet—serious far less on account of its "personal errors," than of its intrinsic gravity, though its author has thought fit to give it a witty and sarcastic tone. He analyzes and criticises "the materialist doctrine, which, in our time, is proclaimed with so much pomp, and resisted with so much passion. 'Matter is all I want,' says the physicist; 'give me its atoms alone, and I will explain the universe.'" It is thought, even by Mr. Martineau's intimate friends, that in this pamphlet he is answering me. I must therefore ask the reader to contrast the foregoing travesty with what I really do say regarding atoms: "I do not think that he (the materialist) is entitled to say that his molecular groupings and motions *explain* every thing. In reality, they explain nothing. The utmost he can affirm is the association of two classes of phenomena, of whose real bond of union he is in absolute ignorance." This is very different from saying, "Give me its atoms alone, and I will explain the universe." Mr. Martineau continues his dialogue with the physicist: "'Good,' he says; 'take as many atoms as you please. See that they have all that is requisite to Body' [a metaphysical B], 'being homogeneous extended solids.' 'That is not enough,' he replies; 'it might do for Democritus and the mathematicians, but I must have something more. The atoms must not only be in motion, and of various shapes, but also of as many kinds as there are chemical elements; for how could I ever get water if I had only hydrogen elements to work with?' 'So be it,' Mr. Martineau consents to reply, 'only this is a considerable enlargement of your specified datum' [where, and by whom specified?]—'in fact, a conversion of it into several; yet, even at the cost of its monism' [put into it by Mr. Martineau] 'your scheme seems hardly to gain its end; for by what manipulation of your resources will you, for example, educe consciousness?'"

This reads like pleasantry, but it deals with serious things. For the last seven years the question proposed by Mr. Martineau and my answer to it have been accessible to all. Here, briefly, is the question: "A man can say 'I feel, I think, I love,' but how does consciousness infuse itself into the problem?" And here is the answer: "The passage from the physics of the brain to the corresponding facts of consciousness is unthinkable. Granted that a definite thought and a definite molecular action in the brain occur simultaneously; we do not possess the intellectual organ, nor apparently any rudiment of the organ, which would enable us to pass, by a process of reasoning,

from one to the other. They appear together, but we do not know why. Were our minds and senses so expanded, strengthened, and illuminated, as to enable us to see and feel the very molecules of the brain; were we capable of following all their motions, all their groupings, all their electric discharges, if such there be; and were we intimately acquainted with the corresponding states of thought and feeling, we should be as far as ever from the solution of the problem, 'How are these physical processes connected with the facts of consciousness?' The chasm between the two classes of phenomena would still remain intellectually impassable."[1]

Compare this with the answer which Mr. Martineau puts into the mouth of *his* physicist, and with which I am generally credited by Mr. Martineau's readers: "'It (the problem of consciousness) does not daunt me at all. Of course you understand that all along my atoms have been affected by gravitation and polarity; and now I have only to insist with Fechner on a difference among molecules; there are the *inorganic*, which can change only their *place*, like the particles in an undulation; and there are the *organic*, which can change *their order*, as in a globule that turns itself inside out. With an adequate number of these, our problem will be manageable.' 'Likely enough,' we may say ['entirely unlikely,' say I], 'seeing how careful you are to provide for all emergencies; and if any hitch should occur in the next step, where you will have to pass from mere sentiency to thought and will, you can again look in upon your atoms, and fling among them a handful of Leibnitz's monads, to serve as souls in little, and be ready, in a latent form, with that Vorstellungsfähigkeit which our picturesque interpreters of Nature so much prize.'"

"But surely," continues Mr. Martineau, "you must observe that this 'matter' of yours alters its style with every change of service: starting as a beggar, with scarce a rag of 'property' to cover its bones, it turns up as a prince when large undertakings are wanted. 'We must radically change our notions of matter,' says Prof. Tyndall; and then, he ventures to believe, it will answer all demands, carrying 'the promise and potency of all terrestrial life.' If the measure of the required 'change in our notions' had been specified, the proposition would have had a real meaning, and been susceptible of a test. It is easy traveling through the stages of such an hypothesis; you deposit at your bank a round sum ere you start, and, drawing on it piecemeal at every pause, complete your grand tour without a debt."

The last paragraph of this argument is forcibly and ably stated. On it I am willing to try conclusions with Mr. Martineau. I may say, in passing, that I share his contempt for the picturesque inter-

[1] Bishop Butler's reply to the Lucretian in the Belfast Address is all in the same strain.

pretation of Nature, if accuracy of vision be thereby impaired. But the term Vorstellungs-fähigkeit, as used by me, means the power of definite mental presentation, of attaching to words the corresponding objects of thought, and of seeing these in their proper relations, without the interior haze and soft penumbral borders, which the theologian loves. To this mode of "interpreting Nature" I shall to the best of my ability now adhere.

Neither of us, I trust, will be afraid or ashamed to begin at the alphabet of this question. Our first effort must be to understand each other, and this mutual understanding can only be insured by beginning low down. Physically speaking, however, we need not go below the sea-level. Let us, then, travel in company to the Caribbean Sea, and halt upon the heated water. What is that sea, and what is the sun which heats it? Answering for myself, I say that they are both *matter*. I fill a glass with the sea-water and expose it on the deck of the vessel; after some time the liquid has all disappeared, and left a solid residue of salts in the glass behind. We have mobility, invisibility—apparent annihilation. In virtue of

> "The glad and secret aid
> The sun unto the ocean paid,"

the water has taken to itself wings and flown off as vapor. From the whole surface of the Caribbean Sea such vapor is rising; and now we must follow it—not upon our legs, however, nor in a ship, nor even in a balloon, but by the mind's eye—in other words, by that power of Vorstellung which Mr. Martineau knows so well, and which he so justly scorns when it indulges in loose practices.

Compounding, then, the northward motion of the vapor with the earth's axial rotation, we track our fugitive through the higher atmospheric regions, obliquely across the Atlantic Ocean to Western Europe, and on to our familiar Alps. Here another wonderful metamorphosis occurs. Floating on the cold, calm air, and in presence of the cold firmament, the vapor condenses, not only to particles of water, but to particles of crystalline water. These coalesce to stars of snow, and afterward fall upon the mountains in forms so exquisite that, when first seen, they never fail to excite rapture. As to beauty, indeed, they put the work of the lapidary to shame, while as to accuracy they render concrete the abstractions of the geometer. Are these crystals "matter?" Without presuming to dogmatize, I answer for myself in the affirmative.

Still, a *formative power* has obviously here come into play which did not manifest itself in either the liquid or the vapor. The question now is, Was not the power "potential" in both of them, requiring only the proper conditions of temperature to bring it into action? Again I answer for myself in the affirmative. I am, however, quite willing to discuss with Mr. Martineau the alternative hypothesis, that

an imponderable formative soul unites itself with the substance after its escape from the liquid. If he should espouse this hypothesis, then I should demand of him an immediate exercise of that Vorstellungsfähigkeit, with which, in my efforts to think clearly, I can never dispense. I should ask, At what moment did the soul come in? Did it enter at once or by degrees; perfect from the first, or growing and perfecting itself contemporaneously with its own handiwork? I should also ask whether it was localized or diffused? Does it move about as a lonely builder, putting the bits of solid water in their places as soon as the proper temperature has set in? or is it distributed through the entire mass of the crystal? If the latter, then the soul has the shape of the crystal; but if the former, then I should inquire after its shape. Has it legs or arms? If not, I would ask it to be made clear to me how a thing without these appliances can act so perfectly the part of a builder? (I insist on definition, and ask unusual questions, if haply I might thereby abolish unmeaning words.) What were the condition and residence of the soul before it joined the crystal? What becomes of it when the crystal is dissolved? Why should a particular temperature be needed before it can exercise its vocation? Finally, is the problem before us in any way simplified by the assumption of its existence? I think it probable that, after a full discussion of the question, Mr. Martineau would agree with me in ascribing the building power displayed in the crystal to the bits of water themselves. At all events, I should count upon his sympathy so far as to believe that he would consider any man unmannerly who would denounce me for rejecting this notion of a separate soul, and for holding the snow-crystal to be "matter."

But then what an astonishing addition is here made to the powers of matter! Who would have dreamed, without actually seeing its work, that such a power was locked up in a drop of water? All that we needed to make the action of the *liquid* intelligible was the assumption of Mr. Martineau's "homogeneous extended atomic solids," smoothly gliding over one another. But had we supposed the water to be nothing more than this, we should have ignorantly defrauded it of an intrinsic architectural power, which the art of man, even when pushed to its utmost degree of refinement, is incompetent to imitate. I would invite Mr. Martineau to consider how inappropriate his figure of a fictitious bank-deposit becomes under these circumstances. The "account current" of matter receives nothing at my hands which could be honestly kept back from it. If, then, "Democritus and the mathematicians" so defined matter as to exclude the powers here proved to belong to it, they were clearly wrong, and Mr. Martineau, instead of twitting me with my departure from them, ought rather to applaud me for correcting them.

The reader of my small contributions to the literature which deals with the overlapping margins of science and theology will have

noticed how frequently I quote Mr. Emerson. I do so mainly because in him we have a poet and a profoundly religious man, who is really and entirely undaunted by the discoveries of science, past, present, or prospective. In his case Poetry, with the joy of a bacchanal, takes her graver brother Science by the hand, and cheers him with immortal laughter. By Emerson scientific conceptions are continually transmuted into the finer forms and warmer hues of an ideal world. Our present theme is touched upon in the lines—

> "The journeying atoms, primordial wholes
> Firmly draw, firmly drive by their animate poles."

As regards veracity and insight these few words outweigh, in my estimation, all the formal learning expended by Mr. Martineau in these disquisitions on force, in which he treats the physicist as a conjurer, and speaks so wittily of atomic polarity. In fact, without this notion of polarity—this "drawing" and "driving"—this attraction and repulsion, we stand as stupidly dumb before the phenomena of crystallization as a Bushman before the phenomena of the solar system. The genesis and growth of the notion I have endeavored to make clear in my third lecture on "Light," and in the article "Crystals and Molecular Force," published in this volume.

Our future course is here foreshadowed. A Sunday or two ago I stood under an oak planted by Sir John Moore, the hero of Corunna. On the ground near the tree little oaklets were successfully fighting for life with the surrounding vegetation. The acorns had dropped into the friendly soil, and this was the result of their interaction. What is the acorn? what the earth? and what the sun, without whose heat and light the tree could not become a tree, however rich the soil, and however healthy the seed? I answer for myself as before—all "matter." And the heat and light which here play so potent a part are acknowledged to be motions of matter. By taking something much lower down in the vegetable kingdom than the oak, we might approach much more nearly to the case of crystallization already discussed, but this is not now necessary.

If, instead of conceding the sufficiency of matter here, Mr. Martineau should fly to the hypothesis of a vegetative soul, all the questions before asked in relation to the snow-star become pertinent. I would invite him to go over them one by one, and consider what replies he will make to them. He may retort by asking me "Who infused the principle of life into the tree?" I say in answer that our present question is not this, but another—not who made the tree, but what *is* it? Is there any thing besides matter in the tree? If so, what, and where? Mr. Martineau may have begun by this time to discern that it is not "picturesqueness," but cold precision, that my Vorstellungs-fähigkeit demands. How, I would ask, is this vegetative soul to be presented to the mind; where did it flourish before

the tree grew, and what will become of it when the tree is sawn into planks, or consumed in fire?

Possibly Mr. Martineau may consider the assumption of this soul to be as untenable and as useless as I do. But, then, if the power to build a tree be conceded to pure matter, what an amazing expansion of our notions of the "potency of matter" is implied in the concession! Think of the acorn, of the earth, and of the solar light and heat—was ever such necromancy dreamed of as the production of that massive trunk, those swaying boughs and whispering leaves, from the interaction of these three factors? In this interaction, moreover, consists what we call *life*. It will be seen that I am not in the least insensible to the wonder of the tree; nay, I should not be surprised if, in the presence of this wonder, I feel more perplexed and overwhelmed than Mr. Martineau himself.

Consider it for a moment. There is an experiment, first made by Wheatstone, where the music of a piano is transferred from its sound-board, through a thin wooden rod, across several silent rooms in succession, and poured out at a distance from the instrument. The strings of the piano vibrate, not singly, but ten at a time. Every string subdivides, yielding not one note, but a dozen. All these vibrations and subvibrations are crowded together into a bit of deal not more than a quarter of a square inch in section. Yet no note is lost. Each vibration asserts its individual rights; and all are, at last, shaken forth into the air by a second sound-board, against which the distant end of the rod presses. Thought ends in amazement when it seeks to realize the motions of that rod as the music flows through it. I turn to my tree and observe its roots, its trunk, its branches, and its leaves. As the rod conveys the music, and yields it up to the distant air, so does the trunk convey the matter and the motion—the shocks and pulses and other vital actions—which eventually emerge in the umbrageous foliage of the tree. I went some time ago through the greenhouse of a friend. He had ferns from Ceylon, the branches of which were in some cases not much thicker than an ordinary pin—hard, smooth, and cylindrical—often leafless for a foot or more. But at the end of every one of them the unsightly twig unlocked the exuberant beauty hidden within it, and broke forth into a mass of fronds, almost large enough to fill the arms. We stand here upon a higher level of the wonderful: we are conscious of a music subtiler than that of the piano, passing unheard through these tiny boughs, and issuing in what Mr. Martineau would opulently call the "clustered magnificence" of the leaves. Does it lessen my amazement to know that every cluster, and every leaf—their form and texture—lie, like the music in the rod, in the molecular structure of these apparently insignificant stems? Not so. Mr. Martineau weeps for "the beauty of the flower fading into a necessity." I care not whether it comes to me through necessity or through freedom, my delight in it is all the

same. I see what he sees with a wonder superadded. To me as to him—nay, to me more than to him—not even Solomon in all his glory was arrayed like one of these.

I have spoken above as if the assumption of a soul would save Mr. Martineau from the inconsistency of crediting pure matter with the astonishing building power displayed in crystals and trees. This, however, would not be the necessary result; for it would remain to be proved that the soul assumed is not itself matter. When a boy, I learned from Dr. Watts that the souls of conscious brutes are mere matter. And the man who would claim for matter the human soul itself, would find himself in very orthodox company. "All that is created," says Fauste, a famous French bishop of the fourth century, "is matter. The soul occupies a place; it is inclosed in a body; it quits the body at death, and returns to it at the resurrection, as in the case of Lazarus; the distinction between hell and heaven, between eternal pleasures and eternal pains, proves that, even after death, souls occupy a place and are corporeal. God only is incorporeal." Tertullian, moreover, was quite a physicist in the definiteness of his conceptions regarding the soul. "The materiality of the soul," he says, "is evident from the evangelists. A human soul is there expressly pictured as suffering in hell; it is placed in the middle of a flame, its tongue feels a cruel agony, and it implores a drop of water at the hands of a happier soul. *Wanting materiality*," adds Tertullian, "*all this would be without meaning.*" One wonders what would have happened to this great Christian father amid the roaring lions of Belfast. Could its excellent press have shielded him from its angry pulpits, as it sheltered me?[1]

I have glanced at inorganic Nature—at the sea, and the sun, and the vapor, and the snow-flake—and at organic Nature as represented by the fern and the oak. That same sun which warmed the water and liberated the vapor, exerts a subtiler power on the nutriment of the tree. It takes hold of matter wholly unfit for the purposes of nutrition, separates its nutritive from its non-nutritive portions, gives the former to the vegetable, and carries the others away. Planted in the earth, bathed by the air, and tended by the sun, the tree is traversed by its sap, the cells are formed, the woody fibre is spun, and the whole is woven to a texture wonderful even to the naked eye, but a million-fold more so to microscopic vision. Does consciousness mix in any way with these processes? No man can tell. Our only ground

[1] The foregoing extracts, which M. Alglave recently brought to light for the benefit of the Bishop of Orleans, are taken from the sixth lecture of the "Cours d'Histoire Moderne" of that most orthodox of statesmen, M. Guizot. "I could multiply," continues M. Guizot, "these citations to infinity, and they prove that in the first centuries of our era the materiality of the soul was an opinion not only permitted, but dominant." Dr. Moriarty, and the synod which he recently addressed, obviously forget their own antecedents. Their boasted succession from the early Church renders them the direct offspring of a "materialism" more "brutal" than any ever enunciated by me.

for a negative conclusion is the absence of those outward manifestations from which feeling is usually inferred. But even these are not entirely absent. In the greenhouses of Kew we may see that a leaf can close, in response to a proper stimulus, as promptly as the human fingers themselves; and while there Dr. Hooker will tell us of the wondrous fly-catching and fly-devouring power of the Dionæa. No man can say that the feelings of the animal are not represented by a drowsier consciousness in the vegetable world. At all events, no line has ever been drawn between the conscious and the unconscious; for the vegetable shades into the animal by such fine gradations, that it is impossible to say where the one ends and the other begins.

In all such inquiries we are necessarily limited by our own powers: we observe what our senses, armed with the aids furnished by science, enable us to observe; nothing more. The evidences as to consciousness in the vegetable world depend wholly upon our capacity to observe and weigh them. Alter the capacity, and the evidence would alter too. Would that which to us is a total absence of any manifestation of consciousness be the same to a being with our capacities indefinitely multiplied? To such a being I can imagine not only the vegetable, but the mineral world, responsive to the proper irritants; the response differing only in degree from those exaggerated manifestations which, in virtue of their grossness, appeal to our weak powers of observation.

Our conclusions, however, must be based, not on powers that we can imagine, but upon those that we possess. What do they reveal? As the earth and atmosphere offer themselves as the nutriment of the vegetable world, so does the latter, which contains no constituent not found in inorganic nature, offer itself to the animal world. Mixed with certain inorganic substances—water, for example—the vegetable constitutes, in the long-run, the sole sustenance of the animal. Animals may be divided into two classes, the first of which can utilize the vegetable world immediately, having chemical forces strong enough to cope with its most refractory parts; the second class use the vegetable world mediately; that is to say, after its finer portions have been extracted and stored up by the first. But in neither class have we an atom newly created. The animal world is, so to say, a distillation through the vegetable world from inorganic nature.

From this point of view all three worlds would constitute a unity, in which I picture life as immanent everywhere. Nor am I anxious to shut out the idea that the life here spoken of may be but a subordinate part and function of a higher life, as the living, moving blood is subordinate to the living man. I resist no such idea as long as it is not dogmatically imposed. Left for the human mind freely to operate upon, the idea has ethical vitality; but, stiffened into a dogma, the inner force disappears, and the outward yoke of a usurping hierarchy takes its place.

The problem before us is, at all events, capable of definite state-

ment. We have on the one hand strong grounds for concluding that the earth was once a molten mass. We now find it not only swathed by an atmosphere, and covered by a sea, but also crowded with living things. The question is, How were they introduced? Certainty may be as unattainable here as Bishop Butler held it to be in matters of religion; but in the contemplation of probabilities the thoughtful mind is forced to take a side. The conclusion of Science, which recognizes unbroken causal connection between the past and the present, would undoubtedly be that the molten earth contained within it elements of life, which grouped themselves into their present forms as the planet cooled. The difficulty and reluctance encountered by this conception arise solely from the fact that the theologic conception obtained a prior footing in the human mind. Did the latter depend upon reasoning alone, it could not hold its ground for an hour against its rival. But it is warmed into life and strength by the emotions—by associated hopes, fears, and expectations—and not only by these, which are more or less mean, but by that loftiness of thought and feeling which lifts its possessor above the atmosphere of self, and which the theologic idea, in its nobler forms, has through ages engendered in noble minds.

Were not man's origin implicated, we should accept without a murmur the derivation of animal and vegetable life from what we call inorganic nature. The conclusion of pure intellect points this way and no other. But this purity is troubled by our interests in this life, and by our hopes and fears regarding the life to come. Reason is traversed by the emotions, anger rising in the weaker heads to the height of suggesting that the compendious shooting of the inquirer would be an act agreeable to God and serviceable to man. But this foolishness is more than neutralized by the sympathy of the wise; and in England at least, so long as the courtesy which befits an earnest theme is adhered to, such sympathy is ever ready for an honest man. None of us here need shrink from saying all that he has a right to say. We ought, however, to remember that it is not only a band of Jesuits, weaving their schemes of intellectual slavery, under the innocent guise of "education," that we are opposing. Our foes are to some extent they of our own household, including not only the ignorant and the passionate, but a minority of minds of high calibre and culture, lovers of freedom, moreover, who, though its objective pull be riddled by logic, still find the ethic life of their religion unimpaired. But while such considerations ought to influence the *form* of our argument, and prevent it from ever slipping out of the region of courtesy into that of scorn or abuse, its *substance*, I think, ought to be maintained and presented in unmitigated strength.

In the year 1855 the chair of Philosophy in the University of Munich happened to be filled by a Catholic priest of great critical penetration, great learning, and great courage, who bore the brunt of

battle long before Döllinger. His Jesuit colleagues, he knew, inculcated the belief that every human soul is sent into the world from God by a separate and supernatural act of creation. In a work entitled "The Origin of the Human Soul," Prof. Froschammer, the philosopher here alluded to, was hardy enough to question this doctrine, and to affirm that man, body and soul, comes from his parents, the act of creation being, therefore, mediate and secondary only. The Jesuits keep a sharp lookout on all temerities of this kind, and their organ, the *Civiltà Cattolica*, immediately pounced upon Froschammer. His book was branded as "pestilent," placed in the Index, and stamped with the condemnation of the Church.[1]

It will be seen in the "Apology for the Belfast Address" how simply and beautifully the great Jesuit Perrone causes the Almighty to play with the sun and planets, desiring this one to stop, and another to move, according to his pleasure. To Perrone's Vorstellung God is obviously a large Individual who holds the leading-strings of the universe, and orders its steps from a position outside it all. Nor does the notion now under consideration err on the score of indefiniteness. According to it, the Power whom Goethe does not dare to name, and whom Gassendi and Clerk Maxwell present to us under the guise of a "Manufacturer" of atoms, turns out annually, for England and Wales alone, a quarter of a million of new souls. Taken in connection with the dictum of Mr. Carlyle, that this annual increment to our population are "mostly fools," but little profit to the human heart seems derivable from this mode of regarding the Divine operations.

But if the Jesuit notion be rejected, what are we to accept? Physiologists say that every human being comes from an egg, not more than $\frac{1}{120}$th of an inch in diameter. Is this egg matter? I hold it to be so, as much as the seed of a fern or of an oak. Nine months go to the making of it into a man. Are the additions made during this period of gestation drawn from matter? I think so undoubtedly. If there be any thing besides matter in the egg, or in the infant subsequently slumbering in the womb, what is it? The questions already asked with reference to the stars of snow may be here repeated. Mr. Martineau will complain that I am disenchanting the babe of its wonder; but is this the case? I figure it growing in the womb, woven by a something not itself, without conscious participation on the part of either father or mother, and appearing in due time, a living miracle, with all its organs and all their implications. Consider the work accomplished during these nine months in forming the eye alone

[1] King Maximilian II. brought Liebig to Munich; he helped Helmholtz in his researches, and loved to liberate and foster science. But he did far more damage to the intellectual freedom of his country through his concession of power to the Jesuits in the schools, than his superstitious predecessor Ludwig I. Priding himself on being a German prince, Ludwig would not tolerate the interference of the Roman party with the political affairs of Bavaria.

—with its lens, and its humors, and its miraculous retina behind. Consider the ear with its tympanum, cochlea, and Corti's organ—an instrument of three thousand strings, built adjacent to the brain, and employed by it to sift, separate, and interpret, antecedent to all consciousness, the sonorous tremors of the external world. All this has been accomplished not only without man's contrivance, but without his knowledge, the secret of his own organization having been withheld from him since his birth in the immeasurable past, until the other day. Matter I define as that mysterious thing by which all this is accomplished. How it came to have this power is a question on which I never ventured an opinion. If, then, Matter starts as "a beggar," it is, in my view, because the Jacobs of theology have deprived it of its birthright. Mr. Martineau need fear no disenchantment. Theories of evolution go but a short way toward the explanation of this mystery; while, in its presence, the notion of an atomic Manufacturer and Artificer of souls raises the doubt whether those who entertain it were ever really penetrated by the solemnity of the problem for which they offer such a solution.

There are men, and they include among them some of the best of the race of men, upon whose minds this mystery falls without producing either warmth or color. The "dry light" of the intellect suffices for them, and they live their noble lives untouched by a desire to give the mystery shape or expression. There are, on the other hand, men whose minds are warmed and colored by its presence, and who, under its stimulus, attain to moral heights which have never been overtopped. Different spiritual climates are necessary for the healthy existence of these two classes of men; and different climates must be accorded them. The history of humanity, however, proves the experience of the second class to illustrate the most pervading need. The world will have religion of some kind, even though it should fly for it to the intellectual whoredom of "spiritualism." What is really wanted is the lifting power of an ideal element in human life. But the free play of this power must be preceded by its release from the torn swaddling-bands of the past, and from the practical materialism of the present. It is now in danger of being strangled by the one, or stupefied by the other. I look, however, forward to a time when the strength, insight, and elevation, which now visit us in mere hints and glimpses during moments "of clearness and vigor," shall be the stable and permanent possession of purer and mightier minds than ours—purer and mightier, partly because of their deeper knowledge of matter and their more faithful conformity to its laws.

# OPOSSUMS AND THEIR YOUNG.

By Prof. W. S. BARNARD.

IN the "Perfect Description of Virginia," 1649, the opossum was noticed as "a beast that hath a bagge under her belly, into which she takes her young ones, if at any time affrighted, and carries them away." Lawson says: "She is the wonder of all animals. The female doubtless breeds her young at her teats, for I have seen them stick fast thereto, when they have been no bigger than a small raspberry, and seemingly inanimate. She has a pouch or false belly wherein she carries her young, after they are from those teats, till they can shift for themselves. . . . If a cat has nine lives, this creature surely has nineteen; for if you break every bone in their skin, and mash their skull, leaving them for dead, you may come an hour after, and they will be gone quite away. . . . Their fur is not esteemed nor used, save that the Indians spin it into girdles and garters." Aside from its curious appearance and habits, the opossum (Fig. 1) possesses an unusual interest from being our typical, and the only North American representative of that large order of peculiar mammals known as marsupials. Its mode of reproduction long remained a mystery, and even at

Fig. 1.—Common Virginia Opossum (*Didelphys Virginiana*).

this day almost nothing is known of its development, which, when thoroughly understood, must explain the origin of the pouch and other parts characterizing marsupials, and their relationship to allied groups. Having had some experience with these animals, and examined seven sets of young ones,[1] at important stages of development, I think it may be worth while to record some of the observations made.

With the general proportions of (but a longer nose than) the common rat, almost the size of a domestic cat, it presents a rather disagreeable appearance and odor. A dense coat of light-gray wool, with scattered long hairs interspersed, covers the body, while the short ears,

[1] The writer is indebted to Prof. Wilder, of Cornell University, and to Mr. Alexander Agassiz, Curator of the Museum of Comparative Zoölogy, at Cambridge, Massachusetts, for specimens kindly loaned him for examination.

the eyes, the long pointed nose, the feet and tail, are colored quite dark. The strong, round, slender tail is destitute of hair, but covered, like the beaver's, with scales. But the most peculiar feature of this animal is the mammary pocket, or marsupium, formed by a folding-in of the skin on the abdomen. Its character is marked by wonderful cunning and stupidity combined. The daytime it spends in slothful idleness, but prowls about nocturnally seeking for food. Walking or slowly ambling at an awkward gait, it proceeds from place to place, usually following the borders of streams and ponds, often wading where the water is shallow. But its limbs seem best adapted to climbing; the plantigrade, hand-like feet, with thumbs [1] opposable to the fingers, and the long, prehensile tail, strongly indicate scansorial habits and arboreal life. Among the trees it manifests astonishing agility, climbing or swinging from branch to branch with perfect safety, and may be seen hanging by one or more of its feet, or by its tail alone, while busily engaged gathering and eating the wild-grapes, or haw, or persimmon, of which it is peculiarly fond, or robbing birds'-nests of their eggs or young. A varied diet suits its omnivorous appetite, and it fares promiscuously on fruits, vegetables, eggs, insects, worms, reptiles, small quadrupeds, and birds, often stealing domestic fowls. It commonly hides among vines and branches, in hollow trees or logs, or in holes in the ground. In these places also its nests of grass and leaves are found. In autumn, the opossums become excessively fat, and are then prized for food in the Southern States, especially by the negroes, whose fondness for hunting them and eating their flesh has already exterminated them from many localities where they abounded plentifully before. Their flesh, when cooked, resembles roast-pig. The animal is usually sullen, stupid, and slow, but if attacked assumes a terribly fierce attitude, snarls, utters a kind of hiss and low growl, and will often bite ferociously, though at the first blow will usually feign death, and no amount of torture will make it revive or show a sign of suffering, but when beaten and left for dead it will

[1] In the October "Miscellany" (p. 758) of this JOURNAL, some of the facts concerning my contributions to the myology of the apes and man appeared incorrectly reported. Since the opossum's foot was wrongly referred to as being typical and unlike the hand of man, the mistake may be corrected here. The comparison of man's foot with the opossum's was unfortunate; the right idea was expressed, but a wrong illustration chosen. The fact is, the opossum is *pedimanous*, having an opposable thumb, as was stated in a paper presented at the same time with the above. It has a rather highly-differentiated foot, whereas the contrary was supposed.

Few, if any, animals outside the groups of the quadrumana and the opossum family have the parts of their muscles so specialized that one toe can be used without moving all the others.

Instead of "one *communis* muscle," there are several in every typical foot. My papers show that the so-called "proprius" muscles, such as the special extensors of the index, thumb, little finger, etc., which characterize the hands of man and some of the apes, are but parts differentiated off from one or another of the "communis" muscles, and are found as parts of those muscles in lower animals with more typical feet.

often crawl away as soon as its enemy is gone. Its great endurance is also shown by the fact that when fat it can live for three or four weeks without food or water.

The female is very fond of her young, enjoying with them that domestic felicity portrayed by Florian in his happy fable, "La Sarigue

Fig. 2.—Merian's Opossum (*Didelphys Dorsigera*) with Young.

et ses petits," and she will offer every resistance, and suffer greatly, to prevent any one looking into her pouch to examine her offspring.

In Europe, Asia, and Africa, not a single marsupial exists. Our only species, *Didelphys Virginiana*, the opossum, is found from the Great Lakes to the Gulf, and from ocean to ocean; but it has several relatives in South America, where about twenty species exist, such as the sarigue, shupati, and carigueya, of Brazil. In some of these the pouch is rudimentary, affording little protection to the young, which hang fast to the nipples until able to jump about, and then are carried on the back of the female, where they cling to her wool and gain additional support by coiling their tails around hers. Perhaps the most cunning of this sort is the so-called Merian's oppossum (*Didelphys dorsigera*), of Surinam, represented in Fig. 2. Also, the yopock (*Cheironectes palmatus*) is peculiarly interesting on account of its aquatic habits and webbed feet, adapted to swimming. Its foot also has a long tubercle, which has been mistaken for a sixth toe, and the mouth is furnished with large cheek-pouches. It inhabits holes along the streams of Brazil, and lives on small aquatic animals, spawn of fish, etc. Its mode of life reminds one of the ornithorhynchus and the otter. A specimen of this species was caught alive near Pará, in a fish-trap similar to the kind of basket with a funnel-shaped opening used for catching eels. Although marsupial animals are so exceed-

ingly rare in other parts of the world, the kangaroos and almost all of the great variety of animals of Australia belong to this group. Thus it appears they are mostly tropical.

The earliest fossil mammals known appear to be marsupials allied to the opossum. In the bone-caverns of Brazil quantities of bones of opossums, such as live in that country now or similar, are found. One species of *Didelphys* was found fossil in the Paris Basin, of Eocene formation. Other relatives of the opossum have been found in a fossil state, associated with the palæotherium, anoplotherium, and other extinct pachydermous quadrupeds; but the most remarkable are found in Jurassic rocks, as the earliest fossil mammals known. Their discovery in this ancient reptilian age in the limestone of Stonesfield was so extraordinary that attempts were made, on the one hand, to prove that their remains were reptilian; on the other, to prove that the rocks were of Tertiary origin; but it has been established, beyond all doubt, that these animals originated in this early reptilian age, and, probably, by descent, either directly or indirectly, from not very remote reptilian ancestry. This relationship is indicated, not only by the fossil remains of marsupials, but also by the anatomical and embryonic characters of marsupials and monotremes, so far as known. The organization of marsupials seems to be a kind of reptilian and mammalian combination, as has been shown by the valuable investigations of Prof. Owen, Dr. Coues, and others.

The monotremes present the lowest grade of mammalian organization, in many respects approaching closely to the oviparous classes of birds and reptiles. It is probably through these that the marsupials have gained some reptilian characters. The opossum, for example, has "a genuine reptilian skull," as Dr. Coues has remarked in his estimable memoir on the anatomy of this animal.

The main difficulty in tracing out the genealogy of marsupials is that our knowledge of them is confined chiefly to the living forms, while these must be but a small remnant of the whole group as it existed in ancient times, when its members inhabited every land on the face of our globe. Even in the imagination we cannot resurrect the manifold varieties of the past. But, in all probability, Prof. Haeckel is right in believing that this group affords a series of forms connecting the lower apes or lemuroids above them with the monotremes below. This would bring some of the marsupials within the lineage of human ancestry, and, before all others, the opossums seem most closely allied to the lemuroid apes. Indeed, they have already been grouped with man and the apes, although their structure hardly warrants such a classification. Storr congregated into one group all mammals with an opposable thumb. Also, Ogilby adopted the name cheiropeds for the same group, and subdivided it into Bimana (men), Quadrumana (monkeys), and Pedimana (Semiadæ and opossums).

The characters of groups are generally arranged into categories

intended to show how groups are distinct from each other; but, if it is equally fair to arrange those characters in such a way as to show the affinities of groups with each other, and what they have in common, we may say briefly that the placental mammals are connected with the marsupials by having—1. Nipples; 2. Free clavicles; 3. An embryonal cloaca, and by these characters both groups are distinguished from the monotremes below them; the marsupials and monotremes are united by having in common—1. Marsupial bones; 2. Undeveloped bigeminal bodies; 3. No placenta, and by these characters

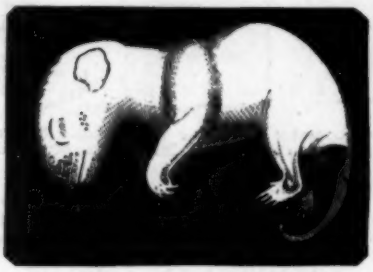

FIG. 3.—YOUNG OPOSSUM. Natural Size.

are distinguished from the placental mammals above; while the monotremes join with the reptiles in possessing—1. United clavicles; 2. A permanent cloaca; 3. No nipples, and by these characters are distinguished from the marsupials above. A great many more characters and facts from the comparative anatomy, embryology, and palæology, could have been used in this comparison; but those given are enough to show how characters usually regarded as *distinctive* only may also at the same time be viewed as *connective*.

The order of living marsupials presents remarkable diversity of structure and habits, containing herbivorous, insectivorous, and carnivorous species; yet we find all these traits combined in one and the same species, the opossum. It is probable that, by adaptation to similar modes of life, the marsupials have developed groups parallel to those of the placental mammals. However, it is certain the Quadrumana seem represented by the Phalangers, the Carnivora by the Dasyuri, Insectivora by the Phascogales, Ruminantia by the kangaroos, and Edentata by the Monotremes. Rodents and bats are numerous in Australia, but only one of the former is marsupial, and none of the latter. The subdivisions of the order are indicated by the modifications of the extremities and digestive system. A gradual transition is found passing from the Phalangers through the Paramelidæ to the kangaroos. All arboreal species have an opposable thumb. This thumb is rudimentary or wanting in the terrestrial species, but in both the carnivorous and herbivorous groups we find a gradual transition to the species possessing a well-developed thumb; thus the

Didelphidæ (opossums) have a well-developed thumb; in some of the Dasyuridæ it becomes very small, while a tolerably distinct thumb characterizes the Phascogales; a rudimentary thumb in Dasyurus; no external thumb in *D. Maujei*, but its metatarsal exists, while in Thylacinus even its metatarsal is gone.

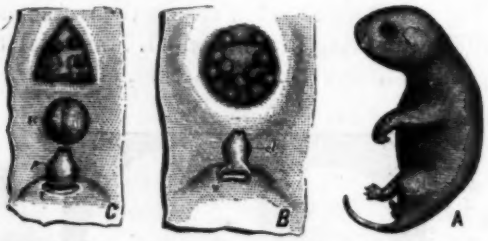


FIG. 4.—A, YOUNG FEMALE OPOSSUM (*Didelphys Virginiana*). Natural Size. B, Marsupium, clitoris, and vent of the same, enlarged; C, Marsupium, penis, and vent of a male of the same litter, enlarged.

Below the marsupials stands the group of Monotremes, including the remarkable Australian Ornithorhynchus and Echidna. In the former the openings of the milk-glands on the abdomen are not marked by any elevation or depression; but in Echidna we find a similar pair of glands, the opening of each becoming depressed at maturity, so as to form a small pit, into which the nose of the young is inserted and attached, where it remains pendant and nourished while its development advances. This pair of little pits may be regarded as the beginning of the bilateral pocket so largely developed in some marsupials. If we can imagine that these depressions have become so deep as to envelop not only the nose of the young, but also its whole body, we can understand the evolution of a marsupial from something lower. At the same time we should notice that these depressions are just the opposite of what we find in the higher mammalia, where the mammary glands form larger or smaller abdominal or pectoral prominences. The milk-glands of Ornithorhynchus seem primitive, while the depressed glands of Echidna and the marsupials, and the elevated glands of higher mammals, may be viewed as differentiations of the same.

The opossum is the animal on which the first observations of marsupial reproduction were made. At first the young, found in an imperfect condition within the pouch, were not examined closely enough to disclose their real nature. They were regarded as formless and inanimate. Even in the "Natural History of New York," Part I., the young is spoken of as "a small gelatinous body, not weighing more than a grain." But these ideas of the early observers still exist in the popular mind, and are as imperfect as their explanations as to how the young originated. The peculiar character of the young led to the belief that they must have developed from the parents' teats, by a kind of metamorphosis or budding process. This gemmiparous

theory existed already in Tyson's time, and was discussed by him. But to-day we have a more correct knowledge of their mode of reproduction, which so long remained clouded with mystery.

An animal born so premature as the little opossum must necessarily perish from exposure, were it not for the curious provision for its protection and the constant supply of milk afforded in the pouch of the female. The internal cavity of the adult female marsupium seems to be formed by an infolding of the external skin. From its opening on the median line of the abdomen the pouch extends backward and laterally, forming a kind of bilateral pocket. From the posterior wall of this about thirteen teats project. To these the young are attached after birth. The two so-called marsupial bones are found in both the male and female Virginian opossums, as well as in some of the South American opossums, which have only a rudimentary pouch, and the monotremes, which have no pouch at all. The investigations of Prof. Owen have shown that these bones are no essential part of the marsupium, although formerly regarded as such; they attach to the anterior border of the pelvis and lie against the mammary glands, where the cremaster muscle winds around them, and makes them act to compress the glands and force out the milk into the throats of the young, which at first seem too feeble to suck.

The young opossums are born as almost helpless little bodies, with mouth and fore-limbs well developed. The transfer of the embryo from the uterus to the pouch has not been observed, but this must be done as with the kangaroo, where it is believed that the mother takes each new-born embryo between her lips and places it upon one of the nipples, which it grasps firmly with its mouth and the claws of its fore-feet. Immediately after birth, the young opossums are found hanging upon the mammary glands fixed in the above manner, each with the hind part of its body free and pendant. At first, the mouth is a transverse, gaping fissure; but, when attached to the nipple, its corners soon grow up, leaving only a small, round pore surrounding the neck of the teat, which enlarges, so that the suckling cannot let go nor fall off, but hangs on without any exertion. Each of the largest fœtal specimens (Fig. 3) I have examined was covered with scattered hairs. The nose was large and blunt, unlike that of the adult. These measured, from the tip of the nose to the ear, 17 millimetres; from the ear to the base of the tail, 39 millimetres; length of the tail, 20 millimetres. Those of the second size (Fig. 4, A) were much smaller, and, in general appearance, looked more like opossums than the next larger size. Perhaps they were of a different species. These were, from the tip of the nose to the ear, 8 millimetres; from the ear to the base of the tail, 27 millimetres; length of the tail, 10 millimetres. The other specimens formed a very good series down to those of the smallest size, which were taken from the uterus. These smallest specimens (Figs. 5, 6) measured, from the tip of the nose to the ear,

3.1 millimetres; from the ear to the tail, 8.0 millimetres; the tail, 3.2 millimetres. Thus the total length of the smallest was 14.3 millimetres, or about one-half an inch. These smaller ones resemble the hippopotamus more than the opossum. Although found within the parent, they were, apparently, nearly ready to be born. A set of sixteen of these was taken from the uterus by Prof. Wilder. As the mother had but thirteen nipples, it is evident that improvidence would allow three embryos to perish. Sometimes as many as eighteen are brought forth, and often only twelve nipples exist. No attachment of the embryos to the uterine walls has been discovered, hence no true placenta is known. Still a kind of umbilicus is formed,

FIGS. 5, 6.—FRONT AND SIDE VIEWS OF SMALLEST EMBRYO OPOSSUM (*D. Virginiana*). Enlarged; entire length when straightened out, one-half inch.

and its cicatrix marks the embryo as it did in Prof. Owen's kangaroo, where it wrongly led to the supposition that a placenta might have been attached. At birth, the hind-limbs appear as short stumps, with their flattened ends presenting slight marginal elevations, the beginnings of toes. These toes and legs gradually elongate. Soon each toe has one joint, and the inner toe becomes set off from the rest. Later, the two longer fingers show two joints, and, finally, the inner toe becomes a thumb with two joints, while each finger has three; and now the hind-foot closely resembles the hand of the higher quadrumana and man, while its fore-feet, much earlier developed, remain more animal-like, the great-toe being set off not so far from the others, but the fingers quite long. The hind-limbs are primarily much shorter than the front, but, developing faster, soon equal and afterward outgrow the others. The same is true of the young kangaroo, where the hind-limbs, shortest at first, finally become many times longer than those in front. Thus we see that what is smallest in the embryo

may become largest in the adult. At birth, the nostrils are large, with a high rim; but the eyes are covered beneath the skin, and the ears are represented by small elevations on the sides of the head, while the lips have a remarkable development and peculiar covering, which reminds us of the first embryonic traces of the duck-like bill of ornithorhynchus. The tongue has a peculiar papillated groove above, to fit the nipple, and three very large papillæ on its base. The larynx and epiglottis project so high into the broad pharynx that the milk swallowed passes in two currents, one on either side. A very large three-lobed thymus gland lies above the heart. Only a rudiment of this exists in the adult. The heart is large, and situated on the median line. Its position changes somewhat as it grows older. The lungs are equal in size. Curiously, the œsophagus enters the stomach near its pyloric end. A very large gland lies on the cardiac end of the stomach. Prof. Owen, speaking of the character of the stomach in marsupials, says: "The stomach is simple in the genera Didelphys, Myrmecobius, and Parameles, and likewise simple in Dasyurus and Phalangista; also in the kaola and wombat, but in these two animals it is provided with a glandular apparatus situated to the left of the cardiac orifice." This is so large in the young Didelphys, that it is curious it does not exist when the animal is fully developed. In the possession of this organ, the young opossum agrees with the old kaola and wombat, but the old opossum has developed a stage further, so that the organ becomes rudimentary, or disappears. The cæcum is relatively twice as large as in the adult. The optic lobes of the brain were relatively larger, and the cerebral lobes somewhat smaller than when full grown. When first born, the male and female are, externally, exactly alike; clitoris and penis are large external organs, just in front of the vent, and so much alike, that it is impossible to distinguish the female from the male by these parts, so markedly different at maturity. Even in the oldest specimens studied, the same similarity of size and form of these parts exists, but the female organ stands nearer to the margin of the vent. Some time after birth, the testes descend into a large scrotum, which has a peculiar position, being at some distance in front of the penis. This is the first external sexual difference, for, although the marsupium begins to appear about the same time, it is remarkable that the male at first has as good a pouch as the female. This is first seen as a cluster of very low papillæ on the abdomen, nearly surrounded by a slight ridge. Slowly this ridge rises higher, and the depression extends itself deeper and more laterally, while the outer edge becomes a fold of skin growing inward toward the median line, until, finally, only a narrow opening is left. The marsupium of the male never becomes fully developed, but gradually diminishes in size; still it was well marked in the largest specimens studied.

To the embryologist every one of these curious facts has great

significance. We have seen how organs exactly alike in the beginning may differentiate before our eyes into parts altogether dissimilar, just as individual animals of a like kind may have their progeny gradually modified from generation to generation, until, finally, different races are produced from a common ancestry. The adult opossum has rather slender and delicate limbs and fingers, and a long, slender, pointed nose; hence it may naturally be wondered that her offspring, even at such an early period of development, should have the parts of the body of an opposite character, they being, as is shown in Fig. 3, wonderfully bulky and clumsy, more like those of the hippopotamus than any thing else. But, if we look to its possible ancestry, and find something similar, we can discover a tolerably satisfactory reason for this by regarding it as inherited. Going back to the Diluvial formation, we find the remains of huge fossil marsupials with similar coarse, bulky proportions. Such were the Diprotodon and Nototherium of New Holland. The skull of the former is three feet long, really surpassing that of the hippopotamus in clumsiness, while its body and limbs were built in the same bulky style, and it is probable that numerous smaller marsupials of the same pattern existed in those remote ages. The embryo opossums show resemblance to lower animals in the general shape of the body, in the early form of the brain, the peculiarities of the lips, the thymus gland, the glandular apparatus of the stomach, the early conditions of the reproductive and urinary organs, and the primitive condition of the mammary glands. Peculiar embryonic resemblances are found in the young of every animal of which the embryology is known, and these facts have no meaning at all to us unless they mean inheritance and descent.

## IDOL-WORSHIP AND FETICH-WORSHIP.[1]

By HERBERT SPENCER.

### I.

FACTS already named show how sacrifices to the man recently dead pass into sacrifices to his preserved body. We have seen that to the corpse of a Tahitian chief daily offerings were made on an altar by a priest; and the ancient Central Americans performed kindred rites before bodies dried by artificial heat. That, along with a developed system of embalming, this grew into mummy-worship, Peruvians and Egyptians have furnished proof. Here the thing to be observed is that, while believing the ghost of the dead man to have gone away, these peoples had confused notions, either that it

[1] From advance-sheets of the "Principles of Sociology."

was present in the mummy, or that the mummy was itself conscious. Among the Egyptians, this was clearly implied by the practice of sometimes placing their embalmed dead at table. The Peruvians, who by a parallel custom betrayed a like belief, also betrayed it in other ways. By some of them the dried corpse of a parent was carried round the fields that he might see the state of the crops. How the ancestor, thus recognized as present, was also recognized as exercising authority, we see in this story given by Santa Cruz. When his second sister refused to marry him, "Huayna Capac went with presents and offerings to the body of his father, praying him to give her for his wife, but the dead body gave no answer, while fearful signs appeared in the heavens."

The primitive idea that any property characterizing an aggregate inheres in all parts of it, implies a corollary from this belief. The soul, present in the body of the dead man preserved entire, is also present in preserved parts of his body. Hence the faith in relics. Ellis tells us that, in the Sandwich Islands, bones of the legs, arms, and sometimes the skulls, of kings and principal chiefs, are carried about by their descendants, under the belief that the spirits exercise guardianship over them. The Crees carry bones and hair of dead persons about for three years. The Caribs, and several Guiana tribes, have their cleaned bones "distributed among the relatives after death." The Tasmanians show "anxiety to possess themselves of a bone from the skull or the arms of their deceased relatives." The Andamanese "widows may be seen with the skulls of their deceased partners suspended from their necks."

This belief in the power of relics leads in some cases to direct worship of them. Erskine tells us that the natives of Lifu, Loyalty Islands, who "invoked the spirits of their departed chiefs," also "preserve relics of their dead, such as a finger-nail, a tooth, a tuft of hair, . . . and pay divine homage to it." Of the New Caledonians Turner says: "In cases of sickness, and other calamities, they present offerings of food to the skulls of the departed." Moreover, we have the evidence furnished by conversation with the relic. Lander says: "In the private fetich-hut of the King Adólee, at Badagry, the skull of that monarch's father is preserved in a clay vessel placed in the earth." He "gently rebukes it if his success does not happen to answer his expectations." Similarly, Catlin describes the Mandans as placing the skulls of their dead in a circle. Each wife knows the skull of her former husband or child—

"and there seldom passes a day that she does not visit it, with a dish of the best-cooked food. . . . There is scarcely an hour in a pleasant day, but more or less of these women may be seen sitting or lying by the skull of their child or husband—talking to it in the most pleasant and endearing language that they can use (as they were wont to do in former days), and seemingly getting an answer back."

Thus propitiation of the man just dead leads to propitiation of his preserved body or a preserved part of it; and the ghost is supposed to be present in the part as in the whole.

Any one asked to imagine a transition from worship of the preserved body, or a preserved part of it, to idol-worship, would probably fail; but transitions, such as imagination does not suggest, actually occur.

The object worshiped is sometimes a figure of the deceased, made partly of his remains and partly of other substances. Landa says the Yucatanese

"cut off the heads of the ancient lords of Cocom, when they died, and, as if to cook them, cleared them from flesh; they then sawed off half of the top of the head, leaving the anterior part with the jawbones and teeth, and to these half-skulls they joined what they wanted in flesh with a certain cement, and made them as like as possible to those to whom they belonged; and they kept them along with the statues and the ashes. All were kept in the oratories of their houses beside their idols, and were greatly reverenced and assiduously cared for. On all their festivals they offered them food." . . . In other cases they "made for their fathers wooden statues," left "the occiput hollow," put in ashes of the burnt body, and attached "the skin of the occiput off the corpse."

The Mexicans had a different method of joining some of the deceased's substance with an effigy of him. When a dead lord had been burned, says Camargo, "they carefully collected the ashes, and, after having kneaded them with human blood, they made of them an image of the deceased, which was kept in memory of him." And from Camargo we also learn that images of the dead were worshiped.

A transitional combination partially unlike in kind occurs: sometimes the ashes are contained in a man-shaped receptacle of clay. Of the Yucatanese the writer above quoted states that—

"The bodies of lords and people of high position were burned. The ashes were put in large urns and temples erected over them. . . . In the case of great lords the ashes were placed in hollow clay statues."

And in yet other cases there is worship of the relics joined with the representative figure, not by inclusion but only by proximity. Thus the Mexicans, according to Gomara—

"closed the box [in which some hair and the teeth of the deceased king were present] and placed above it a wooden figure shaped and adorned like the deceased." Then they "made great offerings, and placed them where he was burnt, and before the box and figure."

Lastly may be named the practice of the Egyptians, who, as their frescoes show, often worshiped the mummy, not as exposed to view, but as inclosed in a case shaped and painted to represent the dead man.

From these examples of transition we may turn to those in which the funeral propitiations are made to a substituted image.

The Mexicans practised cremation: and, when men killed in battle were missing, they made figures of them, and after honoring these burned them and buried the ashes. Here are extracts from Clavigero and Torquemada:

"When any of the merchants died on their journey, . . . his relations . . . formed an imperfect statue of wood to represent the deceased, to which they paid all the funeral honors which they would have done to the real dead body."

"When some one died drowned or in any other way which excluded cremation and required burial, they made a likeness of him and put it on the altar of idols, together with a large offering of wine and bread."

In Africa kindred observances occur. While a deceased King of Congo is being embalmed, says Bastian, a wooden figure is set up in the palace to represent him, and is daily furnished with food and drink. Parkyns tells us that among the Abyssinians mourning takes place on the third day; and, the deceased having been buried on the day of his death, a representation of the corpse does duty instead. Of some Papuan-Islanders Earl states that, when the grave is filled with earth, they collect round an idol and offer provisions to it. Concerning certain Javans we learn from Raffles that after a death a feast is held, in which a man-shaped figure, supported round the body by the clothes of the deceased, plays an important part.

These practices look strange to us; but a stranger thing is that we have so soon forgotten the like practices of civilized nations. In Monstrelet's "Chronicles," book i., the burial of Charles VI. of France is described thus:

"Over the coffin was an image of the late king, bearing a rich crown of gold and diamonds, and holding two shields, one of gold, the other of silver; the hands had white gloves on, and the fingers were adorned with very precious rings. This image was dressed with cloth of gold," etc. . . . "In this state was he solemnly carried to the church of Notre-Dame."

This usage was observed in the case of princes also. Speaking of the father of the great Condé, Madame de Motteville says, "The effigy of this prince was attended (*servit*) for three days, as was customary:" forty days having been the original time during which food was supplied to such an effigy at the usual hours. Monstrelet describes a like figure used at the burial of Henry V. of England; and the effigies of many English monarchs, thus honored at their funerals, are said to have been preserved in Westminster Abbey till they decayed.

With these reminders before us, we ought to have no difficulty in understanding the primitive ideas respecting such representations. When we read that the Coast negroes in some districts "place certain earthen images on the graves;" that the Araucanians fixed over a tomb an upright log, "rudely carved to represent the human frame;"

that, after the deaths of New Zealand chiefs, wooden images, twenty to forty feet high, were erected as monuments—we cannot shut our eyes to the fact that the figure of the dead man is an incipient idol. Could we doubt, our doubt would end on finding the figure persistently worshiped. J. d'Acosta tells us of the Peruvians that—

"each king had, while living, . . . a stone figure representing himself, called Guanqui [huanque]—i. e., brother. This figure was to be worshiped like the Ynca himself, during his life as well as after his death."

So, too, according to Andagoya—

"When a chief died, his house and wives and servants remained as in his lifetime, and a statue of gold was made in the likeness of the chief, which was served as if it had been alive, and certain villages were set apart to provide it with clothing, and all other necessaries."

And, similarly, Cogolludo testifies that the Yucatanese "worshiped the idol of one who is said to have been one of their great captains."

That we may understand better the feelings with which a savage looks at a representative figure, let us recall the kindred feelings produced by representations among ourselves.

When a lover kisses the miniature of his mistress, he is obviously influenced by an association between the appearance and the reality. Even more strongly do such associations sometimes act. A young lady known to me confesses that she cannot bear to sleep in a room having portraits on the walls; and this repugnance is not unparalleled. In such cases, the knowledge that portraits consist of paint and canvas only, fails to expel the suggestion of something more. The vivid representation so strongly arouses the thought of a living personality, that this cannot be kept out of consciousness.

Now, suppose culture absent—suppose there exist no ideas of attributes, law, cause—no distinctions between natural and unnatural, possible and impossible. This associated consciousness of a living presence will then persist. No conflict with established knowledge arising, the unresisted suggestion will become a belief.

Beliefs thus produced in savages have been incidentally referred to. Here are some further examples of them. Kane states that the Chinooks think portraits supernatural, and look at them with the same ceremony as at a dead person. According to Bancroft, the Okanagans "have the same aversion that has been noted on the coast" to having their portraits taken. We learn from Catlin that the Mandans thought the life put into a picture was so much life taken from the original. He also says:

"They pronounced me the greatest *medicine-man* in the world; for they said I had made *living beings*—they said they could see their chiefs alive in two places—those that I had made were a *little* alive—they could see their eyes move."

Nor do more advanced races fail to supply kindred facts. Concerning

the Malagasy, Ellis testifies that friends of the prince, on seeing a photograph of him, took off their hats to it and verbally saluted it.

That which holds of a pictorial representation holds of a carved or sculptured one—holds even more naturally; since the carved representation, being solid, approaches closer to the reality. Where the image is painted and has eyes inserted, this notion of participation in the vitality of the person imitated becomes, in the uncritical mind of the savage, very strong. Any one who remembers the horror a child shows on seeing an adult put on an ugly mask, even when the mask has been previously shown to it, may conceive the awe which a rude effigy excites in the primitive mind. The sculptured figure of the dead man arouses the thought of the actual dead man, which passes into a conviction that he is present.

And why should it not? If the other-self can leave the living body and reënter it; if the ghost can come back and animate afresh the dead body; if the embalmed Peruvian, presently to be resuscitated by his wandering double, was then to need his carefully-preserved hair and nails; if the soul of the Egyptian, after its transmigrations, occupying some thousands of years, was expected to infuse itself once more into his mummy—why should not a spirit go into an image? A living body differs more from a mummy in texture than a mummy does from wood.

That a savage does think an effigy is inhabited we have abundant proofs. Lander, describing the Yorubans, says a mother carries for some time a wooden figure of her lost child, and, when she eats, puts part of her food to its lips. The Samoiedes, according to Bastian, "feed the wooden images of the dead." The relatives of an Ostyak

> "make a rude wooden image, representing, and in honor of, the deceased, which is set up in the yurt, and receives divine honors for a greater or less time, as the priest directs. . . . At every meal they set an offering of food before the image; and, should this represent a deceased husband, the widow embraces it from time to time. . . . This kind of worship of the dead lasts about three years, at the end of which time the image is buried."

Erman, who states this, adds the significant fact that the descendants of deceased priests preserve the images of their ancestors from generation to generation—

> "and, by well-contrived oracles and other arts, they manage to procure offerings for these their family penates, as abundant as those laid on the altars of the universally-acknowledged gods. But that these latter also have an historical origin, that they were originally monuments of distinguished men, to which prescription and the interests of the Shamans gave by degrees an arbitrary meaning and importance, seems to me not liable to doubt."

These Ostyaks, indeed, show us unmistakably how worship of the dead man's effigy passes into worship of the divine idol; for the two are identical. At each meal, placing the dishes before the household

god, they wait (i. e., *fast*) till "the idol, who eats invisibly, has had enough." Moreover, we are told by Bastian, that when a Samoiede goes on a journey, "his relatives direct the idol toward the place to which he has gone, in order that it may look after him." How among the more advanced peoples of these regions there persists the idea that the idol of the god, developed, as we have seen, from the effigy of the dead man, is the residence of a conscious being, is implied by the following statement of Erman respecting the Russians of Irkutsk:

"Whatever familiarities may be permitted between the sexes, the only scruple by which the young women are infallibly controlled is a superstitious dread of being alone with their lovers in the presence of the holy images. Conscientious difficulties of this kind, however, are frequently obviated by putting these witnesses behind a curtain."

Like beliefs are displayed by other races wholly unallied. Of the Sandwich-Islanders, Ellis tells us that, after a death in the family, the survivors worship "an image with which they imagine the spirit is in some way connected;" and also that "Oro, the great national idol, was generally supposed to give the responses to the priests." Concerning the Yucatanese, Fancourt, quoting Cogolludo, says that "when the Itzaex performed any feat of valor, their idols, whom they consulted, were wont to make a reply to them;" and, quoting Villagutierre, he describes the beating of an idol said to have predicted the arrival of the Spaniards, but who had deceived them respecting the result. Even more strikingly shown is this implication in the Quiché legend. Here is an extract from Bancroft:

"And they worshiped the gods that had become stone—Tohil, Avilix, and Hacavitz; and they offered them the blood of beasts, and of birds, and pierced their own ears and shoulders in honor of these gods, and collected the blood with a sponge, and pressed it out into a cup before them. . . . And these three gods, petrified, as we have told, could nevertheless resume a movable shape when they pleased; which, indeed, they often did."

Nor is it among inferior races only that conceptions of this kind are found. In his "Histoire des Musulmans d'Espagne," Dozy, describing the ideas and practices of the idolatrous Arabians, says:

"When Amrolcais set out to revenge the death of his father on the Beni-Asad, he stopped at the temple of the idol Dhou-'l Kholosa to make a consultation by means of the three arrows called command, prohibition, expectation. Having drawn prohibition, he recommenced drawing. But three times he drew prohibition. Thereupon he broke the arrows, and, throwing them into the idol's face, he shouted, 'Wretch, if the killed man had been thy father, thou wouldst not forbid revenging him!'"

# ON A PIECE OF LIMESTONE.[1]

By WILLIAM B. CARPENTER, LL.D., F.R.S.

IN selecting a subject for the lecture which, at the request of the council of the British Association, I undertook to give you during its present meeting, I have been guided by the desire to tell you something that would be new to you in regard to matters with which you are already familiar, and to connect this with the results of my own deep-sea researches, in which I might hope that my own local connection with Bristol would lead you to feel somewhat of a personal interest.

In the rocks that border the Avon on either side, the Bristolian has one of the most characteristic examples of limestone that can be anywhere found; and he has only to go as far as the deep gorge of Cheddar, in the Mendip hills, to find limestone cliffs yet more imposing in height than St. Vincent's rocks; or as far as Chepstow, to see, along the Wye to Tintern Abbey, a still more varied and picturesque display of the same great rock-formation. Its material is sometimes distinguished as the *mountain* limestone, on account of the rugged character it imparts to the districts in which it prevails; while it is now more commonly known as the *carboniferous* (coal-bearing), because it forms the basins or troughs in which the "coal-measures" lie. Now, if you look at a geological map of England, you will trace this limestone as a band lying obliquely northeast and southwest; beginning in Northumberland, passing through Durham and Yorkshire, through Derbyshire (where it forms the romantic scenery about Matlock), then through the midland counties (where, however, it is generally covered up by later formations), and then into Gloucestershire and South Wales, where its relation to the coal-basins is most distinctly marked. Speaking generally, this oblique band divides England into two great areas: one to the northwest, in which the strata that have been brought to the surface, by the crumpling action that has disturbed the crust of the earth during its cooling, are *older* than the carboniferous limestone; the other to the southeast, in which the strata are *newer*. You have not to go far from Bristol to see examples of both. As you pass down the Avon, you observe a succession of limestone-strata lying obliquely one beneath another; and at last you come to an end of these, and find that the next underlying rock is that Old Red Sandstone, of which the massive pier on the Somersetshire side of the suspension bridge is built. And Dundry Hill, which is everywhere so conspicuous, is formed at its lower part of Lias, and at its upper part of Oolite, two later formations which were not deposited until after the

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carboniferous limestone had been uplifted to something near its present position. By measuring the whole length of the succession of limestone-strata that presents itself along the gorge of the Avon, and making the requisite allowance for their slope, the geologist has no difficulty in determining their thickness; and he can say with certainty that, if these successive beds of limestone were piled horizontally upon one another, in the same manner as when they were first formed, their total thickness would exceed 2,000 feet.

Further, you must think of these strata, not only as they present themselves at the surface, but as underlying all our coal-fields, and as probably extending very far beneath the newer strata to the southeast of the dividing band I have just spoken of. Thus, if you look again at the geological map, and notice how the great South Wales coal-field is surrounded by the blue band that indicates the carboniferous limestone, you must think of this limestone as really continuous over the whole of the included area, since it is met with at all points in which the coal-pits are sunk deep enough to reach it. And so in the midland counties, where the map indicates New Red Sandstone and later formations as the surface-strata, these, on being bored through, are found to have coal beneath them; and if we continue the boring downward through the coal-measures, we everywhere come to the limestone-base of this great and important carboniferous series. How far this series extends beneath the newer deposits which form the land of the southeastern portion of England, no geologist can at present say with certainty. If it really underlies them, it must be at an enormous depth, as the results of the Sub-Wealden boring have clearly proved.

Although we are accustomed to speak of the coal-basins of Northumberland, Durham, Yorkshire, Staffordshire, Gloucestershire, Somersetshire, and South Wales, as distinct and separate, it is important to bear in mind that they were probably continuous when the coal-measures were first formed, the "basins" not having then taken shape. This shape was given them by the great disturbance of the older crust of the earth which marked the close of the Palæozoic period, and which brought up the carboniferous limestone into the ridges that now constitute the borders of the basins.

It is this upheaval which has given us access to a vast storehouse of a material of the greatest value to man. Every Bristolian knows the use of this limestone, alike for building and for the making of roads; and the demand for it in the midland counties, to which the Severn affords an easy water-carriage, hastens the already too rapid demolition of his beautiful cliffs. When "burned," i. e., reduced by heat to the condition of "quicklime," it becomes—in virtue of its peculiar power of combining with water—the basis of all mortars and cements. It is as indispensable to the iron-smelter as the coal by which his furnaces are heated, since without its presence he could not reduce

the metal from its ores. It is of no less importance in our great chemical manufactures; such, for example, as that of alkali and bleaching-powder. And the agriculturist makes large use of lime in increasing the productiveness of many soils which would be otherwise comparatively barren.

Now, let us inquire by what agency, and under what circumstances, these vast limestone formations were produced.

You all know that, in particular beds of your Avonside rocks, fossils are met with in great abundance, so that any one who looks for them may find stones that seem almost made up of shells, corals, etc.; but in other beds, some of them of great thickness, scarcely any traces of fossils are found, the whole rock having a uniform sub-crystalline texture. Now, in regard to the first, it is easy to show that the fossils are not merely imbedded in the rock, as they are in a sandstone or a clay, but that the rock is really made up of them; for, when we cut thin slices of such specimens, and examine them with the microscope, we find that the "matrix," or uniting material by which the fossils are held together, is itself composed of minute fragments of the same organic forms, mingled, it may be, with entire specimens of minuter forms. But what are we to say of the massive beds of sub-crystalline stone, in which no trace of fossils is to be found? This question we shall be better able to answer, when we have taken a glance at the other limestones which present themselves in different parts of the great geological succession.

The oldest stratified rocks of which we have any knowledge are those which make up the great *Laurentian* formation, first investigated by the late Sir William Logan, the distinguished geologist who was employed by the Government of Canada to examine the geological structure of that country. This formation chiefly consists of quartz, hornblende, felspar, and other mineral constituents, without any admixture of lime; but near its base is a very remarkable stratum of "serpentine limestone," extending over hundreds of square miles, which has a distinctly organic structure. It is composed of a series of layers, usually very thin, of carbonate of lime alternating with serpentine (magnesian silicate); and the microscopic examination of the calcareous layers first made by Principal Dawson, of Montreal, and afterward extended by myself, has satisfied us that the calcareous layers form a composite fabric of shelly substance, having a regular chambered arrangement, and that the serpentine takes the place of the original animal which occupied these chambers and formed the shell. The animal resembled, in its extreme simplicity of structure, the minute "jelly-specks" by which the Globigerina-shells that cover the Atlantic sea-bed are even now being formed; and differed from it only as the animal of a large composite coral mass differs from that of a simple coral, in extending itself indefinitely by budding; so that a large continuous zoöphytic growth was produced, bearing a strong

resemblance to a coral-reef, instead of the aggregate of minute and separate shells which formed the old Chalk, and which is even now continuing the like formation. I do not know any more remarkable result of microscopic inquiry, than the very distinct evidence it has afforded, in well-preserved specimens of this *Eozoön Canadense*, of a minutely tubular structure, which my own researches into the structure of the *Foraminifera* enable me to identify with certainty as belonging to that type. For we are thus carried back in geological time to a period so extremely remote, that (as Sir William Logan remarked) the oldest fossils previously known are modern in comparison. The investigations of Sir Roderick Murchison have shown that the equivalent of the Laurentian in this country is the "fundamental gneiss" of Scotland, which (as I was shown a few days ago by my friend Mr. Symonds, of Pendock) crops up in the Malvern Hills. Now, in Central Europe this fundamental gneiss has a thickness of 90,000 feet; and near its base Prof. Gümbel has recognized the equivalent of the Canadian *Eozoön*, which must have thus preceded the life of what has been called the "primordial zone," corresponding to our Cambrian rocks, by an interval of time so great that no geologist would venture to assign a limit to it.

The *Cambrian* series, consisting of the grits, sandstones, and slates, that form the mountains of North Wales, scarcely contain any limestone; and we may pass from this to the *Silurian*, or Mid-Wales, series in which we have the well-known Dudley limestone, as well as other less important seams. A slab of Dudley limestone usually shows an extraordinary variety of fossils, among which the most conspicuous are generally the beaded stems of Encrinites; the joints of these stems, when separated by the weathering of the rock, being known in the north as "St. Cuthbert's beads." The whole of this limestone is obviously made up of the corals, shells, crinoids, etc., which we find imbedded in it, and of a matrix formed by comminuted fragments of the like types. A much greater development of these calcareous beds presents itself in North America, the Trenton limestone occurring in the lower Silurians, and the Niagara limestone in the upper; and these rocks have obviously been formed by the same agency as the Dudley limestone.

Passing on now to the *Devonian* series, we find beds of limestone interposed among the sandstones, shales, and conglomerates, of which it is chiefly composed; and these, like the Silurian limestones, are made up of the fossilized remains of corals, shells, crinoids, etc., more or less resembling those of earlier age. It is on the Old Red Sandstone, which is here the uppermost member of the Devonian formation, that, as I have already pointed out, our Carboniferous series immediately rests; its lower beds being distinguished as "limestone shales," on account of the interposition of seams of shale (formed of a mixture of sand and clay) between the layers of limestone.

Postponing for the present the more detailed inquiry into the origin of our own Limestone, of which this general survey is the prelude, I pass on to the *Permian* formation, which rests upon the Carboniferous, and has been upheaved with it, having been deposited previously to the general disturbance that closed the Palæozoic (ancient life) period. Of this Permian formation there are few traces in our part of England; but it has a much greater development in the north, and to it belongs that remarkable bed of Magnesian limestone which comes to the surface in Northumberland and Durham. It is of this stone (selected on account of the durability it has shown in York Minster and other old buildings) that the Houses of Parliament are built. Now, although very few fossils are found in this rock, yet I believe that most geologists would agree that it was originally formed, like limestones generally, by the growth of corals, shells, etc., which separated the carbonate of lime from the sea-water they inhabited; its subsequent conversion into magnesian limestone having been probably effected by the infiltration of water in which magnesia was dissolved. In the Eozoic limestone of Canada, I have myself frequently met with veins of dolomite (magnesian limestone), which retain the general arrangement characteristic of the original shell, although its minute structure has been obliterated by this metamorphic action.

Passing on now to the Secondary or Mesozoic (middle life) series, we find that although the *Trias*, which is the oldest member of it, is represented in England by sandstones alone, there is an important bed of limestone in Germany called the Muschelkalk (shell-limestone), which is interposed between the lower and the upper New Red Sandstones. This bed derives its name from the fact that it is obviously formed by an aggregation of shells, mingled with other fossils, among which the beautiful Lily Encrinite is one of the most abundant. In the *Lias*, which overlies the New Red Sandstone, a considerable portion of lime is generally mingled with the clay deposits of which this formation is principally composed; and some of its beds, especially on the northeast of Yorkshire, are almost entirely calcareous. If you walk along the shore between Saltburn and Whitby, and examine the blocks which have fallen from the lias cliffs above, you will find them to be almost entirely made up of fossils; among which *Belemnites*—conical chambered shells, with solid calcareous "guards," which belonged to animals resembling cuttle-fishes—are specially abundant. And here, as elsewhere, the calcareous matrix in which the fossils are imbedded, though sub-crystalline in some parts, is obviously made up in others of fragments of shell, etc., ground down by the action of the sea in which the deposit was formed. The Lias abounds in the neighborhood of Bristol, and is exposed in many railway-cuttings. These, when in progress some forty years ago, yielded many valuable fossils, especially skeletons of the great Fish-Lizards, which you will see in the Museum of the Bristol Institution. In this neighborhood, also,

you have a splendid illustration of the great *Oolitic* formation, which is almost entirely made up of calcareous deposits that can be clearly traced to an animal origin, although their condition is now very different. The Coral Rag of Oxfordshire is an old coral-reef that has undergone very little change, consisting of fossil corals, and of the shells, crinoids, etc., that lived on the reef. And the "freestones" of Bath and Portland are mainly composed of the fine sand which was formed by the wearing-down of similar reefs, of which the remains are found here and there. The name "oolite" or roe-stone, is given to the whole formation, on account of the resemblance in texture borne by some of its characteristic members to the roe of a fish; but this "oolitic" structure is not peculiar to the Oolitic formation, being found in other limestones, as I shall presently point out to you. A very curious example of the "metamorphic" action by which the texture of a calcareous rock may be so completely altered as to conceal its origin is afforded, by the fact that the beautiful Carrara marble, which is used for statuary, belongs to the Oolitic formation. If this metamorphism, the nature of which I shall presently explain, proceeds further, it will produce large crystals of calc-spar; and I remember that Mr. Baily, the sculptor of the beautiful statue of "Eve at the Fountain," which is in your Fine Arts Gallery, was greatly embarrassed by a vein of calc-spar that ran through the block from which he cut it, and had to let a patch of marble into Eve's back. The next great calcareous formation above the Oolite is the *Chalk*, the material of which is exactly the same as that of limestone, although its texture is so different. Our deep-sea researches have entirely confirmed the opinion which had been previously formed on the basis of microscopic research, that the whole of the enormous mass of Chalk now raised up into the cliffs and downs of the southern portion of England was formed on the bed of the ocean, by the agency of animals—chiefly the minute *Foraminifera*, which separate carbonate of lime from the sea-water as the material of their shells; just as successive generations of fresh-water mussels living in a lake form a bed of calcareous marl on its bottom by the decay of their shells, which sets free in a solid form the lime they have taken from the water that poured it into the lake in solution. We have brought up by the hundred-weight, from depths of three miles in the Atlantic, a white mud, which, when dried, exactly resembles chalk; and this, when examined with the microscope, is found to consist partly of perfect shells of minute *Globigerinæ*, of which many hundreds would only weigh a grain, and partly of what we call *Globigerina ooze*, which is obviously the product of the decay of former generations of similar shells.

In the *Tertiary* or Neozic (modern life) series, we find many limestone deposits of considerable importance, but none so vast as those to which I have previously drawn your attention. The most extensive is the "nummulitic limestone," which is one of the oldest members

of the *Eocene* formation, the earliest of the tertiaries. We find this limestone forming a bed of considerable thickness on the flanks of the Pyrenees, and extending from the shores of the Atlantic along the south of France to the Alps, in some parts of which it shows a thickness of fifteen hundred feet, thence across to Asia Minor, Northern India, and probably to the Pacific shore; while another division of it ranges along Northern Africa, and is especially noteworthy in Egypt, where it rises into the hills that border the Nile for a long distance above Cairo, and furnishes the stone of which the Pyramids are built, and out of which the Sphinx is carved. This stone not merely contained *nummulites*, which are Foraminiferal shells much larger than Globigerinæ (sometimes attaining the size of a half-crown), but is entirely made up of them, and of the fragments of those which have been ground down by the action of the waves, as well as of other shells inhabiting the same sea; all cemented into a solid mass by the process I shall presently describe. Another limestone of more limited extent, belonging to the Eocene age, is found in the neighborhood of Paris, and has furnished the material of which that beautiful city is built. This is entirely made up of the minute Foraminiferal shells termed *Miliolæ*, from their resemblance in size to grains of millet, and is known as "miliolite limestone." So in Malta and in the neighborhood of Vienna, there are limestones entirely composed of shells, corals, and Foraminifera, which were formed in the *Miocene* or Middle Tertiary period. And we have on the coast of Suffolk the calcareous bed known as the "coralline crag," to which equivalents are found in various parts of Europe, that belongs to the *Pliocene* or Later Tertiary period. The material of this bed is chiefly contributed by the calcareous skeletons of composite animals that formerly ranked as zoöphytes, but are now distinguished as *Polyzoa*. Although individually extremely minute, in fact microscopic, they have a very complicated structure, allied to that of the lower Mollusks; and they extend themselves like trees by continuous budding, so that the fabrics they form often have a stony solidity. They abound in our own seas, and, as we shall presently find, they extend very far back in geological time.

Thus, then, we see that, in the case of the Secondary and Tertiary limestones, there can be no question of their production by the agency of animals, which separated carbonate of lime from its solution in sea-water, and formed it into corals, shells, etc., just as similar animals are doing at the present time. And we have in these calcareous deposits many instances of local "metamorphism," which show that the existence of a sub-crystalline, or even of a complete crystalline, arrangement in the particles of carbonate of lime is no proof that the materials of these deposits were not originally drawn from their solution by the agency which formed those whose organic origin is obvious. Thus in the neighborhood of the Giant's Causeway, where volcanic

rocks have burst up through the chalk which forms a long succession of fine cliffs on the Antrim coast, this chalk has been so altered in texture as almost to resemble marble, all trace of its original nature being obliterated. Knowing, as we do, how much more extensive and potent must have been the agencies which were at work in metamorphosing the Palæozoic rocks, we have no difficulty in accounting for the fact that vast beds of our Carboniferous Limestone now show little or no trace of the organic texture which we believe them to have originally possessed. That you may better understand the nature of this metamorphosis, I shall now show you some of the chemical properties of carbonate of lime, which is the material of all calcareous rocks alike, whether showing the perfect crystalline form of calc-spar, the close minutely-crystalline arrangement of marble, the sub-crystalline texture of limestone, the "roe-stone" aggregation of oolite, or the fine powdery condition of chalk.

If we treat a piece of any one of these substances with dilute nitric or muriatic acid, an effervescence is immediately produced by the liberation of carbonic acid, while the lime is dissolved; and this gives a ready way of distinguishing a calcareous from any other rock. In "burning" limestone, on the other hand, the union of the carbonic acid and the lime is dissolved by heat; the carbonic acid is driven off, and the lime remains behind in the condition of "quicklime." This is very greedy (so to speak) of carbonic acid, and is always trying to get it back again. We can dissolve a small quantity of quicklime in water; and if we leave this with a large surface exposed to the air, it gradually recombines with the carbonic acid which it draws from the air; and, as the carbonate is nearly insoluble in water, it falls as a fine white powder, making the water turbid. We may do the same in a moment, by blowing through a pipe into a glass of lime-water, our breath containing a considerable quantity of carbonic acid; and we may then clear the liquid again, by a drop or two of nitric or muriatic acid. But, though insoluble in pure water, carbonate of lime is slightly soluble in water which is already charged with carbonic acid; and, as all rain-water brings down carbonic acid from the air, it is capable of taking up carbonate of lime from the soils and rocks through which it filters; and it thus happens that all springs and rivers, that rise in localities in which there is any kind of calcareous rock, become more or less charged with carbonate of lime kept in solution by an excess of carbonic acid. This is what gives the peculiar character to water which is known as "hardness;" and a water hard enough to curdle soap may be converted into a very "soft" water (as the late Prof. Clark, of Aberdeen, showed) by the simple addition of lime-water, which, by combining with the excess of carbonic acid, causes the precipitation of all the lime in solution in the form of insoluble carbonate, which gradually settles to the bottom, leaving the water clear. It is this solvent power of water charged with carbonic acid,

which has been the great agent in the metamorphism of many calcareous rocks, whereby their texture has been entirely changed, while their composition remains unaltered; and it acts with augmented potency where heat and pressure concur to increase it. Of this we have an example in the action of hot springs highly charged with carbonic acid, such as we often find in volcanic localities; it is to such that the formation of the "travertine" limestone of Italy is due, the carbonate of lime being slowly deposited almost in the condition of marble, when the excess of carbonic acid is disengaged, and the water is dispersed in vapor, by free exposure to air. We have familiar examples of this, on a more limited scale, in the formation of the "stalactites" which hang from the roofs of caves in limestone rocks (as at Cheddar), and in the "stalagmitic" crust formed by their droppings on the floors.

Those who have had opportunities of observing the changes which have taken place in the condition of recent corals that have been upheaved by volcanic action above the level of the sea, in the "area of elevation" to which Mr. Darwin drew attention forty years ago, assure us that their texture is often so changed, that detached pieces of them could not be distinguished from pieces of sub-crystalline limestone. I well remember having first learned this from Mr. S. Stutchbury, who was the curator of the museum here when I was a youth, and who was the first to observe the ring of upraised coral which encircles the cone of the great volcano of Tahiti, and which belongs to the same type as that now forming reefs around the coast of that island. He told me that some specimens of it, which he had collected and brought home, were treated by his brother, a professed mineralogist, as specimens of carboniferous limestone. The formation of oolites, again, may be studied at the present time. When a bed of calcareous sand, formed by the wearing down of shells or corals, is raised above the sea-level, and is penetrated by rain-water charged with carbonic acid, this, dissolving the carbonate of lime of the surface-layer, deposits it again around the grains of the deeper layers, which it invests with concentric coats. Such oolites present themselves in various geological epochs, indicating the similarity of the past and present conditions. There are oolitic beds, for example, in the Clifton rocks; and we thus know that these must have been shore formations; while other beds seem to have been deep-sea deposits, resembling the Globigerina mud of the present Atlantic sea-bottom. For there is in Russia a very extensive bed of limestone belonging to the carboniferous series, which is as completely composed of *Fusulinæ* (an extinct type of foraminifers about the size of a sugar-plum) as the nummulitic limestone is of nummulites. In the clay-seams, again, which we sometimes find interposed between beds of pure limestone, numerous Foraminifera are found well preserved, of which some belong to types still living; and my friend Mr. H. B. Brady, of Newcastle, who has been lately making a microscopic study of the Carboniferous Foraminifera, has found their

remains abundant in specimens of this limestone which do not show any indications of organic structure that are obvious to the naked eye. If the Globigerina-mud were to be subjected to the pressure of an enormous weight of rock deposited above it, and then to the heat and pressure which we know must have accompanied the great crumpling of the earth's crust that made the marked separation between the Palæozoic and the Secondary epochs, we may well believe that it would have been metamorphosed into a limestone closely resembling the least fossiliferous of the Avonside rocks; and we have no difficulty in accounting for the vast thickness of these beds, if we regard them as having been progressively formed on the bottom of a very deep ocean, through a long succession of ages.

That certain beds of the Avonside rocks are ancient Coral-Reefs, cannot be a matter of question; for we find them to be entirely made up of fossil corals, together with the fossilized shells and crinoids which such reefs would have supported. This was especially the case with what used to be called the "black rock" under the sea-wall, which has been nearly all quarried away since, when a boy, I brought home a piece of it as large as I could carry, wondering at such an accumulation of fossils, but without any such understanding of their import as that which I am endeavoring to give you. Every one has heard of the coral reefs and islands, which are popularly said to be "built up" in tropical seas by the agency of "insects," as bees build their waxen combs. And I suppose that every one of you is familiar with specimens of some kind of coral brought home by a seafaring friend, or has seen such in your museum. Now, the fact is, that all these corals are the production of animals resembling in essential points the common sea-anemone, but differing from it in depositing a stony skeleton in the fleshy substance which forms its base, and also in the radiating partitions which surround its stomach. We have on our own shores a small type of the coral-forming polyps, in the little *Caryophyllia*, which, when the animal is expanded, you would take to be a small sea-anemone, but which, when contracted, shrinks down into its stony cup. The *Fungia* of tropical seas is a much larger solitary polyp of the same kind; and you will often meet with its stony disk, four or five inches in diameter, with beautiful thin vertical plates radiating from the centre to the circumference, very much like the "gills" of the under-side of a mushroom (fungus), whence its name is derived. But all the more massive corals are the skeletons of *composite* animals; that is, of polyps which bud like plants, and thus grow to large dimensions. In some cases they form tree-like structures, in which you will find a multitude of polyp-cells, sometimes very small, each having its characteristic arrangement of radiating plates. But in the reef-building corals, the polyp-cells are packed closely together; and the older portion becomes so completely solidified by calcareous deposit that, when broken across, it looks

like a stone. This is especially the case with the *Meandrina*, or brain-stone coral, so named from the resemblance which its furrowed surface bears to the convoluted surface of the brain; hemispherical masses of this coral are not unfrequently to be seen in museums having a diameter of from two to three feet; and in the upraised coral-cliffs of Bermuda they are reported to be five or six feet in diameter. The polyps lie in rows along the furrowed surface, and the active life of the composite mass does not extend far down; its stony interior being the product of its earlier life, as the heart-wood of a tree is the product of previous successions of leaf-buds. But it is no more correct to say that the polyps have built up the stony mass, than it would be to say that the leaves of a tree build up its woody stem, or that our own soft parts build up our bony skeleton. The hard parts are formed in each case by a process of *growth;* soft tissue being first produced as a part of the animal body, and this being subsequently solidified by mineral deposit, the material for which is absorbed by the animal from the sea-water in which it lives.

The admirable researches of Mr. Darwin have shown us that, although the reef-building corals seem unable to live and grow at depths greater than twenty fathoms (one hundred and twenty feet), yet that if their base gradually subsides, at a rate not greater than that of coral-growth, the reef or island will be kept up to the surface by such growth; so that, if we could bore down into it, we might find the coral-structure to have a depth of many hundreds or even thousands of feet. The recent soundings of the Challenger around the Bermuda islands, which are entirely composed of coral, indicate that they form the summit of a pillar rising from a depth of twelve thousand feet; and as we have no instance of a mountain having such a shape, it seems probable that the upper part of this pillar, at any rate, must have been formed of coral, which kept growing upward, in the manner indicated by Mr. Darwin, while the bottom was slowly subsiding. It is commonly supposed by geologists that the limestone beds of which I have been speaking are the result of the metamorphosis of ancient coral formations, which attained their great thickness by continuous growth at their living surface, as their base gradually subsided. But it appears to me that all we know of existing coral formations renders it unlikely that there should have been such a *continuity* of area in ancient coral formations, as would be required to account for the continuity in the area of our great beds of carboniferous limestone; and that this continuity is far better accounted for by supposing them to have been formed in the manner I previously indicated—by the foraminiferal life which recent researches have shown to be even now forming a calcareous deposit over vast areas of the ocean-bottom.

Thus, then, we should regard the beds which show distinct coral-structure as representing reefs or islands of limited extent in the

Palæozoic ocean; while the formation of those beds of vast area, in which few or no traces of animal life are found, may be fairly referred to the agency of minute forms, essentially similar to those of the Old Chalk and of its existing representative (Globigerina-mud), whose habitation is the deep sea.

No inconsiderable proportion of the calcareous material of some of the local beds seems to have been furnished by the stems and bodies of the *Crinoids* (lily-like animals), which abounded in the Palæozoic seas, and of which the representatives at the present time have been proved by recent deep-sea exploration to be much more numerous and widely diffused than was previously supposed. I remember to have seen these very conspicuous in polished sections of the old "black rock;" and certain beds in the limestone of Derbyshire, which are worked for marble chimney-pieces, seem almost entirely composed of their remains. The stems of the Crinoids of the Carboniferous period were not beaded like those of the Dudley (Silurian) limestone, but were cylindrical in form; they had, however, the same jointed structure and central canal; and you will thus readily recognize them when cut either longitudinally, transversely, or obliquely.

It has been further recently shown that *Polyzoa* essentially resembling those of our modern "coralline crag" existed at this epoch, and had a share in the formation of certain beds of the carboniferous limestone. There is a particular bed in St. Vincent's rocks, which has been found by Mr. Stoddart to be composed of fragments of their delicate calcareous fabrics, with Foraminifera, and other small forms of animal life; and he has appropriately named it the *microzoic* bed. And Prof. Young, of Glasgow, has been fortunate enough to find, in a clay-seam of the carboniferous limestone in his neighborhood, a collection of these fabrics preserved entire in the fullest perfection.

Thus we seem justified in the conclusion that the vast strata of carboniferous limestone, which in England alone must cover tens of thousands of square miles, and has a thickness of more than two thousand feet, had their sole origin in the continuous life of innumerable generations of humble animals, which, in times long past, did the work that is still being performed in the depths of our own seas by animals of similar types, which we may believe to be their lineal descendants. I have shown you how we are indebted to their agency for the abundant supplies they have provided of a material most useful—I may say indispensable—to us. Let us take care that, with our larger capacities and higher aims, we strive to promote the welfare of those who come after us, by doing well, each in his station, that which our powers and opportunities best fit us to accomplish.—*Author's advance-sheets.*

# STRANGE MENTAL FACULTIES IN DISEASE.

By HEZEKIAH BUTTERWORTH.

THERE are certain mental mysteries associated with peculiar states of disease, and especially with low, nervous diseases, which discover unexpected powers of mind, and which illustrate some of the conditions on which human life depends, and the laws that govern its continuance. Among these are certain enlargements of the perceptive faculties, and a singular power which the mind seems to possess of acting independently of its organs.

Our attention was recently called to the subject by the mental condition of a near relative, suffering from extreme nervous debility. "I am in constant fear of insanity," she said to me one day, "and I wish I could be moved to some retreat for the insane. I understand my condition perfectly: my reason does not seem to be impaired, but I can think of *two things at the same time.* This is an indication of mental unsoundness, and is a terror to me. I do not seem to have slept at all for the last six weeks. If I sleep, it must be in a succession of vivid dreams that destroy all impression of somnolence. Since I have been in this condition, I seem to have very vivid impressions of what happens to my children who are away from home, and I am often startled to learn that these impressions are correct. I seem to have also a certain power of anticipating what one is about to say, and to read the motives of others. I take no pleasure in this strange increase of mental power; it is all unnatural; I cannot live in this state long, and I often wish that I were dead."

The faculty of memory is one of the first to be obviously affected by disease. When disease for a time seems to suspend the action of this faculty, or visibly to diminish it, the result is not looked upon as phenomenal, for it is common and expected. But when disease increases the power of this faculty, a thing not uncommon, the patient is not unfrequently regarded as possessing more than human wisdom, and the case usually excites comment as one of great mystery. Dr. Steinbech mentions the case of a clergyman who, being summoned to administer the sacrament to an illiterate peasant, found the patient praying aloud in Greek and Hebrew. The case was deemed wellnigh miraculous. After the peasant's death, it was found that he was accustomed in youth to hear the parish minister pray in those languages, and it was inferred that he must have been repeating remembered words without understanding their meaning. Dr. Abercrombie relates the circumstances of a more remarkable case. A poor shepherd-girl was for a time accustomed to sleep in a room adjoining that occupied by an itinerant musician. The man was an artist by education, a lover

of his profession, and often spent a large portion of the night in practising difficult compositions. The violin was his favorite instrument. At last the shepherd-girl fell ill, and was removed to a charitable institution. Here the attendants were amazed at hearing the most exquisite music in the night, in which were recognized finely-rendered passages from the best works of the old masters. The sounds were traced to the shepherd-girl's room, where the patient was found playing the violin in her sleep. Awake, she knew nothing of these things, and exhibited no capacity for music.

A late number of the London *Medico-Chirurgical Review*, in an article on apoplexy, speaks of vivid dreams as a common warning in the first and often unrecognized stages of insanity, heart-disease, and phthisis, and one that it would be well to better understand and heed. Vivid dreaming, which in some cases seems to be a mental illumination, and in others a prophecy of impending ill, precedes many diseases long before the victim is aware of his condition. These dreams sometimes take the forms of waking fancies, double consciousness, and what is called mystic memory. In February, 1829, when Sir Walter Scott was breaking himself down by severe and protracted literary labor, and was suffering the first invasion of ill health which ultimately ended in death, he wrote in his diary on the 17th, that, on the preceding day, at dinner, although in company with two or three old friends, he was strongly haunted by a "sense of preëxistence," a confused idea that nothing that passed was said for the first time; that the same topics had been discussed, and that the same persons had expressed the same opinions before. "There was," he writes, "a vile sense of a want of reality in all that I did or said." Goethe relates that, as he was once in an uneasy and unhealthy state of mind, riding along a foot-path toward Drusenheim, he saw himself on horseback coming toward himself; and similar stories are told of other highly-imaginative persons whose mental balance has been disturbed by over-anxiety or incipient illness.

The states of physical prostration known as *coma somnolentum* and *coma vigil* exhibit, in their largest extent, the poetic capacities of the mind. The impressions, dreams, and illusions, in these conditions, are such as no healthy mind could possibly conceive. The patient seems to live in a charmed world, amid spectral beings and airy people, changing lights, luminous heights, and appalling shadows; in short, no glowing epic or work of the painter's art seems so much as to touch upon such richness of imagery. Mrs. Hemans on her death-bed said that no pen could describe or imagination conceive the visions that passed before her mind, and made her waking hours more delightful than those spent in repose.

Rev. William Tennent, of Freehold, New Jersey, was an overworked student, and was supposed to be far gone in consumption. In a protracted illness he apparently died, and the preparations were made

for his funeral. Not only were his friends deceived in his case, which was one of coma, but he himself was doubly illusioned, for he both thought that he was dead and that his spirit had entered paradise. His soul, as he thought, was borne aloft, to celestial altitudes, and was enraptured with visions of the Deity and angelic hosts. He seemed to dwell in an enchanted region of limitless light and inconceivable splendor. At last an angel came to him and told him that he must go back. Darkness, like an overawing shadow, shut out the celestial glories, and, full of sudden horror, he uttered a deep groan. This dismal utterance was heard by those around him, and prevented him from being buried alive, after all the preparations had been made for the removal of the body.

In certain forms of physical prostration, the mind seems to the patient to be capable of unusual freedom; to be in and out of the body at the same time, to be able to make impressions at a distance, and to have a knowledge of itself and of events transpiring around it quite beyond the usual range of the faculties. In analyzing these seeming powers, it is impossible to separate the imaginary from what may be real, and to determine the exact limit of mental action. Plutarch relates that a certain profligate and profane man, named Thespesius, fell from a great height and was taken up apparently dead. He remained in a state of seeming insensibility for three days, but on the day appointed for the funeral unexpectedly revived, and from this time a remarkable change was observed in his moral conduct and character. On inquiry being made as to the cause of the sudden reformation, he said that, in his state of apparent insensibility, he had been made so clearly to see the relation of mind to matter as to be convinced of the future existence of the soul. After his injury he had supposed himself to be dead, and his spirit to be separated from the body. He had seemed to float in an abysm of light, and to be surrounded by spirits transcendently bright and glorious. One of the latter at last announced to him that he must return to the flesh again, when he suddenly seemed to reappear on earth, as a being from another world. In 1733, Johann Schwerzeger, after a long illness, fell into a comatose state, from which he recovered. He said that he had seen as in a vision *his whole life pass before him*, even events which, before his sickness, he seemed to have quite forgotten. He further stated that he thought he was about to enter a state of rest and happiness, when he was recalled to the world; that he was sorry to have come back, but that he should remain here but two days. His death fulfilled the prediction.

But perhaps the most remarkable of all phenomena of this nature is a certain power a few patients have seemed to possess of "withdrawing from sensation," of becoming at will insensible to pain, and of producing a resemblance of death. Colonel Townsend, an Englishman, who died at the end of the last century, had in his last sickness the

extraordinary power of apparently dying and returning to life again. "I found his pulse sink gradually," wrote Dr. Cheyne, his medical attendant, "so that I could not feel it by the most exact or nice touch. Dr. Raymond could not detect the least motion of the heart, nor Dr. Skrine the least soil of the breath upon the bright mirror held to his mouth. We began to fear that he was actually dead. He then began to breathe softly." The colonel tried this experiment a number of times during his illness, and was able to render himself insensible at will.

Dr. Brown-Séquard, in a course of lectures before the Boston-Lowell Institute, last winter, illustrated many like remarkable powers of mind in mental and physical disease, by cases which had come under his own observation. From such cases it would seem that the mind is largely dependent on physical conditions for the exercise of its faculties, and that its strength and most remarkable powers, as well as its apparent weakness, are often most clearly shown and recognized by some inequality of action in periods of disturbed and greatly-impaired health.

## PROGRESSION AND RETROGRESSION.

By Prof. W. D. GUNNING.

WE walk along a rocky beach when the tide is out. Twice every twenty-four hours this narrow zone is sea and twice it is land. Its tenants are, as itself, a sort of dividing zone between land and sea. The Algæ in the tide-pools will remind you of Confervæ in the ponds. The littorinæ on the rocks will remind you of snails. The shapeless, gelatinous clumps adhering to rocks or wharf-posts will remind you of garden slugs, or naked snails. We will give our attention first to these soft and shapeless clumps.

They will call up no image in the mind until the sea returns, or until you detach one of them, and drop it into a glass of sea-water. You have a Dendronotus, or a Doris, or an Eolis, or an Aplysia.

Out of the shapeless clump comes a form like that of the slug; but the slug in our captive is soon disguised, for along its back, from end to end, rises a fringe of pinkish papillæ. We have an Eolis. What does Eolis do with these papillæ? The last generation of naturalists said, "He breathes with them."

The last generation was too sparing of the knife. We cut through Eolis's back till we reach the stomach, which we find to be a mere expansion of the intestinal tube. This tube extends lengthwise through the body and lies near the *dorsal*, not the ventral side. It branches, and the branches branch again, and run up into the papillæ which stand out like quills on an angry porcupine. The papillæ are supplementary stomachs.

Eolis has no liver. With so much stomach it can carry on the process of digestion without the aid of that organ, so troublesome to man and beast. A row of hepatic cells extending part way along the intestine represents the rudiment of a liver, or its vestige.

Where are the lungs? Nowhere—or, rather, everywhere. No part is specialized and set apart for aërating the blood. In the vital economy of this sea-slug, there is but little division of labor. The surface is soft tissue, covered with vibrating cilia, and currents of water, set in motion by the cilia, flow around the tissue and yield oxygen to its blood.

Perhaps the gelatinous knob you detached was not an Eolis. If your knife reaches a stomach which is not arborescent, you may have a Doris. The dorsal papillæ of Doris are genuine lungs, but they breathe for only part of the body. They aërate only the blood which goes to the liver, an organ which appears now, not as a row of bile-cells, but as a well-defined gland. The foot shares the labor of the lungs, they breathing for the liver, it for the rest of the body.

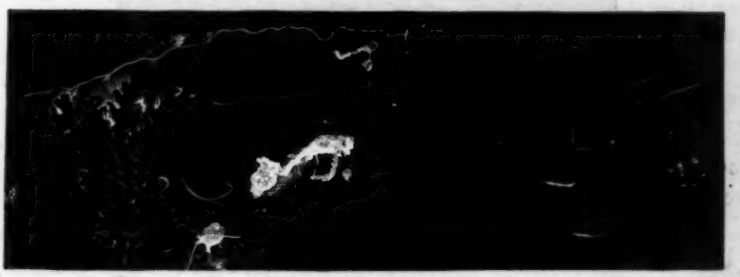

FIG. 1.—DORIS LACINA.

In Eolis the quill-like diverticula of the stomach are placed in rows; in Doris the leaf-like, moss-like, or flower-like branchiæ are gathered into clusters (Fig. 1). Our first woodcut represents a Doris (*Doris lacina*), with two horn-like antennæ on the head; and on the back, at the other extremity, a tuft of crimson leaves finely reticulated and deeply lobed. The second cut represents a Doris (*Doris plumulata*), with frond-like antennæ and a lung resembling tufts of delicate sea-weed wrought into an eight-rayed star. Another Doris wears its lung like a brilliant flower, another like a begemmed tiara. Doris can draw his lungs into his body or throw them out at pleasure (Fig. 2).

Dendronotus may be known, as its name implies, by its branching, tree-like gills. If we leave the rocks and wharf-posts, and examine the laminaria (oar-weed), or ulva (sea-lettuce), we may find another member of this family. Aplysia is known to fishermen under the name of "sea-hare." A hump on its back calls up the image of a camel rather than that of a hare. If you make a dissection you will find that an idea has been borrowed from the camel's stomach as well as

hump. Aplysia has a *row* of stomachs, and, what is strange, the teeth are not inserted in the mouth, but in one of the stomachs. In Aplysia, the liver is better defined than in Doris, and the leaf-like gills aërate blood for the whole body.

The classification of these naked mollusks will be as obvious now to the reader as to the observer.

In Eolis no liver, but a few bile-cells representing its rudiment, or vestige; no lung, every part of the surface respiring for itself; no well-differentiated stomach, but an arborescent intestinal tube.

FIG. 2.—DORIS PLUMULATA.

In Doris (sea-lemon), a liver; respiratory organs in the guise of crown, or star, or leaf, or tufts of sea-weed, organs which serve the liver only; a stomach.

In Aplysia (sea-hare), a better liver, respiratory organs in the form of leaves, organs which serve the whole body; many stomachs.

Eolis stands lowest, Aplysia highest. The series is suggestive of the history of organs, if not of species. It invites special attention to the lung.

In all marine animals except Cetacea, either the entire outer surface absorbs oxygen and exhales carbonic acid, or part of this surface has been differentiated for the function of respiration. In all mammals, and birds, and mature reptiles, part of an *inner* tissue has been differentiated and set apart for the function of respiration. External respiratory organs rise from the skin. Internal respiratory organs rise from the skin of the throat. Internal respiratory organs exist in the fish as a rudiment. External respiratory organs appear in embryotic mammals as vestiges.

The inner lung begins as a little hollow bud on the throat. This bud pushes out another and another, and so on till by continuous budding it becomes a tree-like growth, interlaced with blood-vessels. Let such a bud start from the outer surface, on the back. It will become, according to the mode of secondary budding, a little tree, or leaf, or flower of blood-vessels and vascular tissue—such a lung as adorns the back of Doris.

The history of the inner lung is indicated by fishes and amphibians. The history of the outer lung is indicated in these naked mollusks.

Eolis, which shows us the beginning of a liver, or perhaps the last stage of its reduction, seems to be prehistoric as to the gill. One part of the surface absorbs oxygen as well as another. If we leave the beach and the Eolids for mid-ocean and the Pteropods, we shall find the first shadowing forth of a gill. In the Pteropod one part of the skin is a little more vascular than the rest, and on this part the blood is more freely oxidized. Now "respiratory activity," as Spencer has shown, "aids in the development of respiratory appendages." A larger and larger surface is exposed to the water, and this larger surface, developed partly by Natural Selection, and partly by respiratory activity itself, is attained in multitudinous branchings of the mimic tree, and deep sinuosities of the mimic leaf.

But in Doris, which represents a great advance in gill development over a Pteropod, the gill is still imperfect, and as a respiratory organ it is supplemented by the creeping disk. In Aplysia the gill is carried up to perfection and aërates all the blood.

In the evolution of an organ we have hints as to the evolution of a species.

No interest can attach to such low forms of life as the Eolids unless they teach something of the methods of Nature in originating species. Readers of THE POPULAR SCIENCE MONTHLY will not give their attention to mere description or anecdote. Facts they know do not pass into science until fertilized by ideas. We shall return to Eolis and its family through a study of forms which the eye, not aided by the knife, would report as far removed from them.

A mollusk is a soft, fleshy, sac-like body, with a mantle (pallium) extending from the back in two folds, right and left, around the sides. In the Bryozoan (moss-animal), whose reticulated coral incrusts many shells and sea-weeds, the molluscan type reaches down almost to the polyp. The Bryozoan has a cylindrical body with a tentacular crown. Structurally it is a mollusk, morphologically a polyp. It would seem to be a case in the organic world analogous to that in the inorganic, in which a small portion of a mineral, in crystallizing, forces a large portion of a foreign mineral into its own crystalline form and masks the structure under the shape.

The mantle performs important functions, and it will guide us along a series of transformations. Suppose that the two folds cohere along their edges. The mantle would then become a kind of sac, inclosing the body. If we call it a *tunic*, we might say that the animal is wrapped in its tunic, and this cohering of the tunic-folds would bring us to the order of *Tunicata*.

If we put the dredge down fathoms deep into the sea, it may bring from the bottom a Clavelina, most beautiful of Tunicates. In shape it is a pitcher without handle, an inch high, tapering down to a slender

base, which springs from a creeping gelatinous thread. The mantle is transparent as crystal, and through it you may see, as if suspended in the cavity of the body, what seems the frilled edge of a ribbon of snow-white lace. This is Clavelina's lung. A little sac, seen through the transparent mantle and body walls, contracting and expanding with a slow and measured beat, is Clavelina's heart.

Another cloaked mollusk is Cynthia. It adheres to rocks or pebbles under a few fathoms of ocean, and has something of the form and color of a blood-peach. It is known to watermen under the name of "sea-peach." Its mantle is tough and leathery.[1]

Another and a more interesting member of the cloaked family is the Salpa. In the structure of the heart it marks an advance on Clavelina. Instead of a single pulsating sac, we find an auricle and a ventricle, veins and arteries. But, Nature having advanced from a single to a double heart, it would seem that she did not yet know how to use the improvement. In the Salpa we find the heart incessantly changing its auricle into a ventricle, its ventricle into an auricle, veins into arteries, arteries into veins.

The Salpæ swim freely in the open sea and occur singly, or united in long chains or rings. They are phosphorescent, and a chain of united Salpæ appears like a writhing, fiery serpent gliding over the waves. The Pyrosomes, which are free Salpæ, congregate in vast shoals, and in their phosphorescence glare like pillars of fire, green, unearthly, elfish.

Let the edges of the mantle unite along part of their surface, but remain open at the ends. The animal now will not be completely tunicated. It will be inclosed in a kind of funnel. If, now, such a mantle be drawn out into a siphon to conduct a current of water to the gills, it would be of use to the animal in aiding respiration. The edges of the mantle having united in this way, a siphon-bearing mollusk, like the cockle or solen, would be simply a question of time. Natural Selection would bring it about.

Let the edges of the mantle not unite at all, we shall have a mollusk something like the oyster.

Remove the shell, and an oyster lies before you in irregular, ragged outline. An opening at the sharper end, which lies near the beak of the shell, is the mouth. Around the mouth are four leaf-like bodies, which hang in pairs. The heart is an advance on that of Salpa, not in structure but in behavior. It has settled down into regular work, the auricle always an auricle, and the ventricle always a ventricle. The liver is a decided advance on that of Eolis, although not yet a well-defined gland. The mantle is a fringed, veil-like membrane,

[1] It is known that the mantle of many tunicate mollusks is *non-azotized* matter. Azote is another name for nitrogen, and in various proportions it is found in animal tissues. This is a distinguishing feature between animal (azotized) and vegetal (non-azotized) matter. *Chemically* the plant meets the animal on the back of a tunicate mollusk.

whose folds are not united along their edges. Near the mouth, on the ventral side, is a portion of the surface a little tougher than the rest. This toughened surface on the oyster we shall find as significant as we found the softened vascular patch on the surface of the Pteropod.

The leaf-like bodies which surround the mouth appear as silent members. In some form or other they are present in all mollusks, and in the order of Cephalopods they reach the maximum of development, and appear as long, flexible limbs. In this order—represented by the Octopus—the molluscan type reaches the highest expression. Early in the history of life, the type had unfolded and found expression in Cephalopods of great bulk and of many species. The Cephalopods have long been a waning dynasty (Fig. 3).

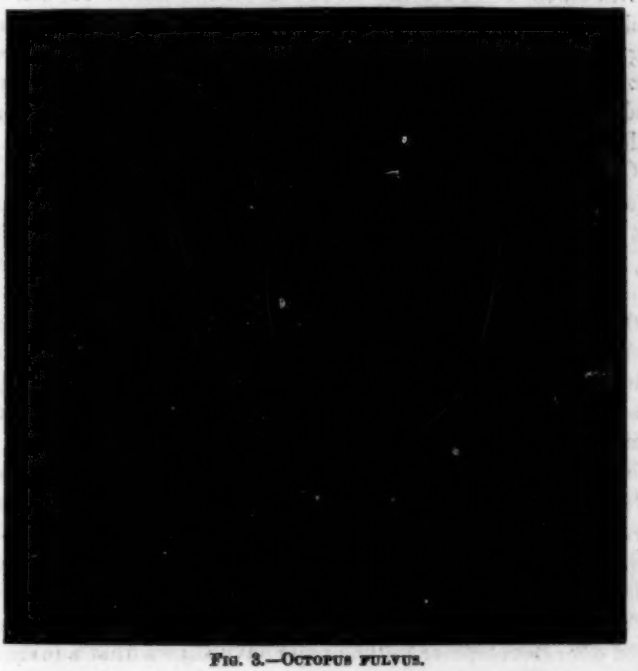

Fig. 3.—Octopus fulvus.

As we have met the palpi—rudimental in the oyster—in other guise in oyster's distant relatives, so we will find that toughened portion, so faintly pronounced in the oyster, expressed with greater distinctness in oysters' nearer relatives. In the mussel this toughened surface supports a bundle of fibres, which protrudes from the shell and adheres to a rock or wharf-post. In the cockle we find this same portion prolonged into a finger-like organ, which performs the office of locomotion. It is called a foot. In the teredo this "foot" has reached the maximum of development, as the palpi in Octopus. But for the rudimental palpi, we might look on the oyster as a degraded

cockle or mussel. But for the toughened surface representing the cockle's foot, we might regard the oyster as a lapsed form of some ancient Cephalopod.

The mantle secretes the shell, and in all bivalves it lies through its whole extent against the shell. Now, in all mollusks, the axis of the body is at first straight, and the body is bisymmetrical. If growth were arrested at an early stage, all mollusks would look alike, and, if the embryotic mantle were to secrete a shell, all these arrested growths would appear as miniature bivalves. They would be symmetrical. But circumstances determine shapes. The mollusk which, in maturity as well as infancy, lives in the open sea, will be exposed to like conditions on either side, and will retain its bilateral symmetry. A mollusk which lies on the sea-bottom will be exposed to unlike conditions, one side being buried in mud and the other bathed in water. As a shrub which grows against a wall loses its symmetry and becomes one-sided, so a young oyster, as soon as it leaves off its roving ways, and fixes its abode on the sea-mud, must begin to develop unsymmetrically. One side and one valve of the shell outgrow the other side and valve. In the Gryphæa, an ancient species of oyster, this over-development of one side is carried further, and, while the right valve is small and flat, the left is deep and partially rolled up. In the Gasteropods, except Chiton, this one-sidedness is carried still further. One side outgrows the other so much that the body takes a spiral form, and one valve, secreted by one fold of the mantle, appears as a spiral shell, while the other valve, secreted by the aborted fold of the mantle, appears as an operculum—a little shelly disk known under the name of "eye-stone." In the snail this one-sided development is carried to the highest pitch of asymmetry. Overgrowth of the right side forces it into a spiral, and the right valve twists around with the body it incloses, while the left valve, which, in the marine Gasteropod, we had found reduced to an operculum, is here completely eliminated.

From the cloaked clavelina to the oyster, we were led, step by step, along successive modifications of the mantle. From the oyster to the snail we have passed, step by step, along successive stages of one-sided over-development. The facts have shown that a bivalve mollusk could not have descended from a univalve. As all mollusks in early life have the axis of the body straight, and the parts symmetrically arranged on either side, we may infer that bilateral symmetry characterized the remote ancestors of the molluscan type. Now, while a mollusk is bisymmetrical or nearly so, if the mantle secretes a shell it must be in in two parts, or, as in Chiton, in many parts. The snail is the last term of our series, and its successive stages of growth should indicate the path along which Nature has moved in the evolution of the unsymmetrical Gasteropod from a symmetrical, oyster-like bivalve (Fig. 4).

Lereboullet has made out the embryology of Limneus, a fresh-

water snail. We need not follow him into details. It will be enough for our purpose to note that from a "mulberry mass"—the egg after segmentation of the yelk—there comes a sort of hemispherical cup. The mouth of the cup changes from a circle to a long slit, and the edges of the slit unite except at one point. The embryo has now taken on the molluscan type. The aperture along the line of the slit is the opening to the sac, the mouth to the coming snail. The line along which the approximated sides of the cup have united is in the trend of a plane which divides the body into right and left sides, equal

FIG. 4.—SYMMETRY. EMBRYOTIC SNAIL: *m*, mouth; *ma*, mantle; *c*, creeping disk; *in*, intestine; *h*, heart (auricle and ventricle in line with the intestinal tube); *r*, remnants of yolk-cell.

and similar. The mantle has begun to form, and as a sort of cap it covers the part of the body opposite the mouth. The intestine begins in a little depression under the mantle and in line with the mouth and stomach. This depression is elongated, becomes a tube, and opens into the stomach. A few days later, traces of a heart appear as two pulsating, globular sacs, placed end to end (Fig. 5).

If development were arrested at this stage, our snail would be bisymmetrical, and, if it had a shell, the shell would be in two equal valves, right and left. But development goes on, and now every step is a departure from right and left symmetry. First, the intestine gets a twist. Other organs are quick to follow. Even the heart moves askance. The two chambers which, a while before, were placed end to end in line with the axis of the body, begin to change position. The receiving chamber moves obliquely to the right and downward, the distributing chamber to the left and upward. The right fold of the mantle spreads rapidly; the left, not at all. The right side of the body grows rapidly; the left remains almost stationary. The right valve of the shell grows rapidly, and twists over with the inclosed body; the left is completely aborted. Now, it is a very significant fact that the only parts which do not share this one-sided overgrowth are the head and creeping disk; and these are the parts which, not being covered by the mantle, do not become incased in the shell. Exposed to the water or the air equally on both sides, they retain their bilateral symmetry.

From a sac-like body, moving freely through the water, and thus exposed equally on both sides to the same environment, and therefore bisymmetrical, we may suppose that all mollusks have been derived. If such a free-moving body became fixed, unless as a stemmed Ascidian, its parts would be differently conditioned as to environment, and the side more favored would outgrow the other. As the first part of the snail's body to bend out of line with the axis is the intestinal canal, we infer that this bend occurred far back in the snail's ancestry. It occurs in the oyster. As the last organ to share the general twist resulting from unequal growth of the sides is the heart, we infer that displacement of this organ occurred later down in the history of the type. It does not occur in the oyster.

FIG. 5.—ASYMMETRY. ADULT SNAIL: *op*, optic tentacle; *œ*, œsophagus; *cn*, cephalic ganglion; *g*, gizzard; *s*, stomach; *l*, liver; *i*, intestine (bent out of line with the axis of the body); *h*, heart (auricle and ventricle not in line with axis or intestinal tube); *v*, vent.

The first step toward a spiral-shelled gasteropod was taken in the first mollusk whose environment on one side was mud or rock, and on the other water. Difference of environment was the first factor in this series of evolutions. Only this would induce one-sidedness, and acting through long periods it might induce excessive one-sidedness. It might carry an oyster as far along in asymmetrical growth as the partially rolled-up oyster called Gryphæa. When asymmetry came to be of advantage to the animal, Natural Selection began and carried it to greater excess, with the aid of other factors—for Nature is too

rich to be limited to one or two efficient causes—carried it to the order of Gasteropods.

In this order we find Eolis, and Doris, and Aplysia. From them our studies have ranged over kindred, near and remote. From their kindred we return, prepared by what we have found to interpret them. In form, these animals do not depart from bilateral symmetry, as from their habits they should not. Each side is exposed in the same way to the same environing element. But the alimentary canal is bent out of line with the axis of the body. The reproductive system is still more askance. It is altogether one-sided. Very suggestive facts. We find one-sided growth without the conditions which induce it. These conditions must have pertained to an ancestor. The bend in the alimentary canal and the displacement of the reproductive organs have been inherited from an ancestor so conditioned in the environment as to produce overgrowth of one side. But the alimentary canal does not bend out of line so much as in the shell-bearing Gasteropods; and in Eolis—in which the last vestige of a shell has disappeared—the canal has become straight. Another suggestive fact. We find in these naked mollusks heredity and abbreviated heredity.[1] Aplysia and Doris inherit the ancestral twist. In Eolis the heritage is cut off.

From symmetry to asymmetry, from a bivalve to a univalve, Nature has moved, closing a cycle of evolution in the snail; from asymmetry back to symmetry, from a shell-bearer to a non-shell-bearer, she is moving in the sea-slugs. In this retrogression, Aplysia has shared the least. It retains the largest shell-vestige; it has the most perfect liver; its gills cover the mantle. Eolis has been carried back the farthest. In this retrogressive movement we may find the *rationale* of Aplysia's many stomachs, and Eolis's branching stomach and hepatic cells. In the snail, perhaps in all Gasteropods, the alimentary

[1] To account for the facts of heredity, Darwin has formulated a theory called *Pangenesis*. To account for the facts of heredity and *abbreviated* heredity Dr. Elsberg has proposed a theory which he calls "*the Conservation of the Organic Molecule*." The biologist must be allowed as much "scientific use of the imagination" as the physicist. If the one must have his atoms and molecules, the other must have his physiological units, his plastic molecules, his "*plastidules*." Let us imagine the first pair of any race, say the human race. A child of the Adam and Eve would be derived wholly from its parents, and, if the plastidules which passed into the embryo were derived equally from each parent, one-half of the Adam would be represented in the child. Now, if some of these organic molecules were to remain latent in the body of the offspring, and pass unchanged into the offspring of the next generation, a smaller portion of the Adam would be repeated in the grandchild. We are to suppose that each plastidule carries so much of the parent, potentially, into the child. At each successive generation less and less of the Adamic plastidules would appear, and less and less of the Adam. We should have a fractional series with unity for numerator, and an ever-increasing number for denominator. At last we should reach a term whose denominator would be infinitely large. It would express the complete elimination of the Adamic plastidules. Now, so long as any plastidules of an ancestor of any degree of remoteness remain, so long will the man or the animal inherit something from that ancestor; so long will atavism occur. When all plastidules of such ancestor are cut off, we have *abbreviated* heredity.

canal develops *isolately*, a section here and another there. Now, a stomach is simply an expanded portion of the canal. Let the tract of the canal be laid in isolated openings, let these openings be elongated, each, into a tube, and let the original openings be marked as pouches along this continuous tube, and we have Aplysia's row of stomachs. It is after the pattern of the digestive tube of an embryotic Gasteropod.

In Eolis the branching alimentary canal lies along the dorsal side, not the ventral. In getting itself straight, it seems to have got itself as near the dorsal papillæ as possible. Now, these papillæ, for a long time mistaken for lungs, for a long time, perhaps, were lungs. We have found that in Doris the gills are connected only with the digestive system, and we may suppose that in some ancestral form of Eolis papilliform gills were connected with this system in the same way, that is, through the liver. Only a slight departure from the normal development would transfer the connection of a gill-bud from one part of the digestive system to another, from the liver to the stomach. If, then, it would be for the advantage of the animal to have more stomach, we can see how, by Natural Selection, all the gill-buds or papillæ would, in the end, cease to respire for the liver and become diverticula of the stomach. What would become of the liver? Losing its lung, it would suffer degradation. It would abort, lapse into a few hepatic cells, and become a mere vestige.

The naked Tunicates are intelligible as initial terms of a molluscan series. The naked Gasteropods are intelligible as final terms of a descending series, as impoverished heirs of an ancient house.

We have chosen for our study these slugs of the sea to develop a phase of evolution not generally understood. Evolution does not imply an unbroken course of progression. It does not imply a tendency in every thing to become something else and better. It is determined by many factors, inner and outer, and, as Spencer has shown, "the coöperation of inner and outer factors works changes until an equilibrium is reached between the organism and its environment."

On the deep-sea bottom the environing actions remain constant age after age, and we find that in the abyssal world a number of species have remained constant since the Cretaceous epoch. On the surface of the sea and on the beach, the conditions of life have not been constant, and surface and littoral species have been more subject to change. The air is more fickle than the sea. It is now warm and now cold; now moist and now dry; now in motion and now at rest: and the aërial fauna must oppose to these outer factors a corresponding adjustment of inner factors. The fauna of this element we should find the most unstable, and so we do. The only insect known to have come down to our times from times so remote as the Cretaceous, unchanged or changed but little, is the tiger-beetle of our sea and lake shores, and the uplands of Colorado. More-

over, an insect at rest is not conditioned as an insect in the air. Let it forsake little by little its aërial life, and rest longer and longer on other bodies. In time it becomes a parasite. The structure it had acquired while in the air becomes useless. The environment being more stable, the opposing actions within are reduced, and the organism lapses into a simpler form. In the insect world we should find the largest number of retrograded species, and so we do. Fleas, bugs, the dream of which sends a shudder through our sleep, creepers in the hair, burrowers in the flesh, form a descending series, each order carrying with it, in the form of vestiges, reminiscences of a higher state when, as winged insects, its ancestors lived in the open air.

Retrogression of this kind has affected higher orders. An amphibious mammal, taking less to the land and more to the water, would lapse in time into a simpler form. The studies of Prof. Wilder on the embryotic dugong seem to show that dugongs and manatees have descended by retrogression from some ancient hippopotamoid mammal.

Retrogression, whose *rationale* is not found in our studies on the Eolids, has affected still higher orders. If the elephants of our day are descendants of the mastodons and mammoths which, in Pleistocene days, possessed North America and Europe, as the investigations of Gaudry wellnigh demonstrate; if the living tigers and lions have descended from species whose remains abound in ancient caves, as is probable; if the "grizzly" of the Rocky Mountains is a modified form of the great cave-bear, once so common in Europe, as naturalists believe; if the anthropoid apes of Africa and tropical Asia are survivals from a race which spread beyond the tropics and ranked somewhat nearer to man, as the *Mesopithecus* of Greece and *Dryopithecus* of France testify out of Miocene strata, the proboscidians, carnivores, and primates have all suffered retrogression, and, at the advent of man, life having reached its zenith, *animal* life began a downward curve. If, in the main, the higher has followed the lower, within this cycle of progression the struggle for life would involve another cycle of retrogression. As the savage in presence of civilization often sinks to lower savagery, so a species, outstripped in the race of life, and left hopelessly behind, degenerates, and finally dies.

And as the two cycles, progression and retrogression, are involved in the life-history of the earth, so the two movements may go on simultaneously in the same species. Man himself is such a species. His brain, and its servant, the hand, have attained the utmost development. His digestive system and his foot have been modified but little from a primitive type. Progression above in that which is most distinctively human may involve retrogression below in that which is distinctively animal.

# GEOGRAPHY AND EVOLUTION.[1]

By Lieutenant-General R. STRACHEY, F. R. S.

IN accordance with the practice followed for some years past by the presidents of the sections of the British Association, I propose, before proceeding with our ordinary business, to offer for your consideration some observations relative to the branch of knowledge with which this section is more specially concerned.

My predecessors in this chair have, in their opening addresses, viewed geography in many various lights. Some have drawn attention to recent geographical discoveries of interest, or to the gradual progress of geographical knowledge over the earth generally, or in particular regions. Others have spoken of the value of geographical knowledge in the ordinary affairs of men, or in some of the special branches of those affairs, and of the means of extending such knowledge. Other addresses, again, have dwelt on the practical influence produced by the geographical features and conditions of the various parts of the earth on the past history and present state of the several sections of the human race, the formation of kingdoms, the growth of industry and commerce, and the spread of civilization.

The judicious character of that part of our organization which leads to yearly changes among those who preside over our meetings, and does not attempt authoritatively to prescribe the direction of our discussions, will no doubt be generally recognized. It has the obvious advantage, among others, of insuring that none of the multifarious claims to attention of the several branches of science shall be made unduly prominent, and of giving opportunity for viewing the subjects which from time to time come before the Association in fresh aspects by various minds.

Following, then, a somewhat different path from those who have gone before me in treating of geography, I propose to speak of the physical causes which have impressed on our planet the present outlines and forms of its surface, have brought about its present conditions of climate, and have led to the development and distribution of the living beings found upon it.

In selecting this subject for my opening remarks, I have been not a little influenced by a consideration of the present state of geographical knowledge, and of the probable future of geographical investigation. It is plain that the field for mere topographical exploration is already greatly limited, and that it is continually becoming more restricted. Although no doubt much remains to be done in obtaining detailed maps of large tracts of the earth's surface, yet there is

[1] Address of the President of Section E, at the Bristol Meeting of the British Association.

but comparatively a very small area with the essential features of which we are not now fairly well acquainted. Day by day our maps become more complete, and with our greatly-improved means of communication the knowledge of distant countries is constantly enlarged and more widely diffused. Somewhat in the same proportion the demands for more exact information become more pressing. The necessary consequence is an increased tendency to give to geographical investigations a more strictly scientific direction. In proof of this I may instance the fact that the two British naval expeditions now being carried on, that of the Challenger and that of the arctic seas, have been organized almost entirely for general scientific research, and comparatively little for topographical discovery. Narratives of travels, which not many years ago might have been accepted as valuable contributions to our then less perfect knowledge, would now perhaps be regarded as superficial and insufficient. In short, the standard of knowledge of travelers and writers on geography must be raised to meet the increased requirements of the time.

Other influences are at work tending to the same result. The great advance made in all branches of natural science limits more and more closely the facilities for original research, and draws the observer of Nature into more and more special studies, while it renders the acquisition by any individual of the highest standard of knowledge in more than one or two special subjects comparatively difficult and rare. At the same time the mutual interdependence of all natural phenomena daily becomes more apparent; and it is of ever-increasing importance that there shall be some among the cultivators of natural knowledge who specially direct their attention to the general relations existing among all the forces and phenomena of Nature. In some important branches of such subjects, it is only through study of the local physical conditions of various parts of the earth's surface and the complicated phenomena to which they give rise that sound conclusions can be established; and this study constitutes physical or scientific geography. It is very necessary to bear in mind that a large portion of the phenomena dealt with by the sciences of observation relates to the earth as a whole in contradistinction to the substances of which it is formed, and can only be correctly appreciated in connection with the terrestrial or geographical conditions of the place where they occur. On the one hand, therefore, while the proper prosecution of the study of physical geography requires a sound knowledge of the researches and conclusions of students in the special branches of science, on the other, success is not attainable in the special branches without suitable apprehension of geographical facts. For these reasons it appears to me that the general progress of science will involve the study of geography in a more scientific spirit, and with a clearer conception of its true function, which is that of obtaining accurate notions of the manner in which the forces of Nature have brought

about the varied conditions characterizing the surface of the planet which we inhabit.

In its broadest sense science is organized knowledge, and its methods consist of the observation and classification of the phenomena of which we become conscious through our senses, and the investigation of the causes of which these are the effects. The first step in geography, as in all other sciences, is the observation and description of the phenomena with which it is concerned; the next is to classify and compare this empirical collection of facts, and to investigate their antecedent causes. It is in the first branch of the study that most progress has been made, and to it indeed the notion of geography is still popularly limited. The other branch is commonly spoken of as physical geography, but it is more correctly the science of geography.

The progress of geography has thus advanced from first rough ideas of relative distance between neighboring places, to correct views of the earth's form, precise determinations of position, and accurate delineations of the surface. The first impressions of the differences observed between distant countries were at length corrected by the perception of similarities no less real. The characteristics of the great regions of polar cold and equatorial heat, of the sea and land, of the mountains and plains, were appreciated; and the local variations of season and climate, of wind and rain, were more or less fully ascertained. Later, the distribution of plants and animals, their occurrence in groups of peculiar structure in various regions, and the circumstances under which such groups vary from place to place, gave rise to fresh conceptions. Along with these facts were observed the peculiarities of the races of men—their physical form, languages, customs, and history—exhibiting on the one hand striking differences in different countries, but on the other often connected by a strong stamp of similarity over large areas.

By the gradual accumulation and classification of such knowledge the scientific conception of geographical unity and continuity was at length formed, and the conclusion established that while each different part of the earth's surface has its special characteristics, all animate and inanimate Nature constitutes one general system, and that the particular features of each region are due to the operation of universal laws acting under varying local conditions. It is upon such a conception that is now brought to bear the doctrine, very generally accepted by the naturalists of our own country, that each successive phase of the earth's history, for an indefinite period of time, has been derived from that which preceded it, under the operation of the forces of Nature as we now find them; and that, so far as observation justifies the adoption of any conclusions on such subjects, no change has ever taken place in those forces, or in the properties of matter. This doctrine is commonly spoken of as the doctrine of evolution, and

it is to its application to geography that I wish to direct your attention.

I desire here to remark that, in what I am about to say, I altogether leave on one side all questions relating to the origin of matter, and of the so-called forces of Nature which give rise to the properties of matter. In the present state of knowledge such subjects are, I conceive, beyond the legitimate field of physical science, which is limited to discussions directly arising on facts within the reach of observation, or on reasonings based on such facts. It is a necessary condition of the progress of knowledge that the line between what properly is or is not within the reach of human intelligence is ill defined, and that opinions will vary as to where it should be drawn; for it is the avowed and successful aim of science to keep this line constantly shifting by pushing it forward; many of the efforts made to do this are no doubt founded in error, but all are deserving of respect that are undertaken honestly.

The conception of evolution is essentially that of a passage to the state of things which observation shows us to exist now, from some preceding state of things. Applied to geography, that is to say to the present condition of the earth as a whole, it leads up to the conclusion that the existing outlines of sea and land have been caused by modifications of preëxisting oceans and continents, brought about by the operation of forces which are still in action, and which have acted from the most remote past of which we can conceive; that all the successive forms of the surface—the depressions occupied by the waters, and the elevations constituting mountain-chains—are due to these same forces; that these have been set up, first, by the secular loss of heat which accompanied the original cooling of the globe; and second, by the annual and daily gain or loss of heat received from the sun acting on the matter of which the earth and its atmosphere are composed; that all variations of climate are dependent on differences in the condition of the surface; that the distribution of life on the earth, and the vast varieties of its forms, are consequences of contemporaneous or antecedent changes of the forms of the surface and climate; and thus that our planet as we now find it is the result of modifications gradually brought about in its successive stages, by the necessary action of the matter out of which it has been formed, under the influence of the matter which is external to it.

I shall state briefly the grounds on which these conclusions are based.

So far as concerns the inorganic fabric of the earth, that view of its past history which is based on the principle of the persistence of all the forces of Nature may be said to be now universally adopted. This teaches that the almost infinite variety of natural phenomena arises from new combinations of old forms of matter, under the action of new combinations of old forms of force. Its recognition has, how-

ever, been comparatively recent, and is in a great measure due to the teachings of that eminent geologist, the late Sir Charles Lyell, whom we have lost during the past year.

When we look back by the help of geological science to the more remote past, through the epochs immediately preceding our own, we find evidence of marine animals—which lived, were reproduced, and died—possessed of organs proving that they were under the influence of the heat and light of the sun; of seas whose waves rose before the winds, breaking down cliffs, and forming beaches of bowlders and pebbles; of tides and currents spreading out banks of sand and mud, on which are left the impress of the ripple of the water, of drops of rain, and of the tracks of animals; and all these appearances are precisely similar to those we observe at the present day as the result of forces which we see actually in operation. Every successive stage, as we recede in the past history of the earth, teaches the same lesson. The forces which are now at work, whether in degrading the surface by the action of seas, rivers, or frosts, and in transporting its fragments into the sea, or in reconstituting the land by raising beds laid out in the depth of the ocean, are traced by similar effects as having continued in action from the earliest times.

Thus pushing back our inquiries we at last reach the point where the apparent cessation of terrestrial conditions such as now exist requires us to consider the relation in which our planet stands to other bodies in celestial space; and, vast though the gulf be that separates us from these, science has been able to bridge it. By means of spectroscopic analysis it has been established that the constituent elements of the sun and other heavenly bodies are substantially the same as those of the earth. The examination of the meteorites which have fallen on the earth from the interplanetary spaces shows that they also contain nothing foreign to the constituents of the earth. The inference seems legitimate, corroborated as it is by the manifest physical connection between the sun and the planetary bodies circulating around it, that the whole solar system is formed of the same descriptions of matter, and subject to the same general physical laws. These conclusions further support the supposition that the earth and other planets have been formed by the aggregation of matter once diffused in space around the sun; that the first consequence of this aggregation was to develop intense heat in the consolidating masses; that the heat thus generated in the terrestrial sphere was subsequently lost by radiation; and that the surface cooled and became a solid crust, leaving a central nucleus of much higher temperature within. The earth's surface appears now to have reached a temperature which is virtually fixed, and on which the gain of heat from the sun is, on the whole, just compensated by the loss by radiation into surrounding space.

Such a conception of the earliest stage of the earth's existence is

commonly accepted, as in accordance with observed facts. It leads to the conclusion that the hollows on the surface of the globe occupied by the ocean, and the great areas of dry land, were original irregularities of form caused by unequal contraction; and that the mountains were corrugations, often accompanied by ruptures, caused by the strains developed in the external crust by the force of central attraction exerted during cooling, and were not due to forces directly acting upward generated in the interior by gases or otherwise. It has recently been very ably argued by Mr. Mallet that the phenomena of volcanic heat are likewise consequences of extreme pressures in the external crust, set up in a similar manner, and are not derived from the central heated nucleus.

There may be some difficulty in conceiving how forces can have been thus developed sufficient to have produced the gigantic changes which have occurred in the distribution of land and water over immense areas, and in the elevation of the bottoms of former seas so that they now form the summits of the highest mountains, and to have effected such changes within the very latest geological epoch. These difficulties in great measure arise from not employing correct standards of space and time in relation to the phenomena. Vast though the greatest heights of our mountains and depths of our seas may be, and enormous though the masses which have been put into motion, when viewed according to a human standard, they are insignificant in relation to the globe as a whole. Such heights and depths (about six miles) on a sphere of ten feet in diameter would be represented on a true scale by elevations and depressions of less than the tenth part of an inch, and the average elevation of the whole of the dry land (about one thousand feet) above the main level of the surface would hardly amount to the thickness of an ordinary sheet of paper. The forces developed by the changes of the temperature of the earth as a whole must be proportionate to its dimensions; and the results of their action on the surface in causing elevations, contortions, or disruptions of the strata, cannot be commensurable with those produced by forces having the intensities, or by strains in bodies of the dimensions, with which our ordinary experience is conversant.

The difficulty in respect to the vast extent of past time is perhaps less great, the conception being one with which most persons are now more or less familiar. But I would remind you that, great though the changes in human affairs have been since the most remote epochs of which we have records in monuments or history, there is nothing to indicate that within this period has occurred any appreciable modification of the main outlines of land and sea, or of the condition of climate, or of the general characters of living creatures; and that the distance that separates us from those days is as nothing when compared with the remoteness of past geological ages. No useful approach has yet been made to a numerical estimate of the duration

even of that portion of geological time which is nearest to us; and we can say little more than that the earth's past history extends over hundreds of thousands or millions of years.

The solid nucleus of the earth with its atmosphere, as we now find them, may thus be regarded as exhibiting the residual phenomena which have resulted on its attaining a condition of practical equilibrium, the more active process of aggregation having ceased, and the combination of its elements into the various solid, liquid, or gaseous matters found on or near the surface having been completed. During its passage to its present state many wonderful changes must have taken place, including the condensation of the ocean, which must have long continued in a state of ebullition, or bordering on it, surrounded by an atmosphere densely charged with watery vapor. Apart from the movements in its solid crust caused by the general cooling and contraction of the earth, the higher temperature due to its earlier condition hardly enters directly into any of the considerations that arise in connection with its present climate, or with the changes during past time which are of most interest to us; for the conditions of climate and temperature at present, as well as in the period during which the existence of life is indicated by the presence of fossil remains, and which have affected the production and distribution of organized beings, are dependent on other causes, to a consideration of which I now proceed.

The natural phenomena relating to the atmosphere are often extremely complicated and difficult of explanation; and meteorology is the least advanced of the branches of physical science. But sufficient is known to indicate, without possible doubt, that the primary causes of the great series of phenomena, included under the general term climate, are the action and reaction of the mechanical and chemical forces set in operation by the sun's heat, varied from time to time and from place to place, by the influence of the position of the earth in its orbit, of its revolution on its axis, of geographical position, elevation above the sea-level, and condition of the surface, and by the great mobility of the atmosphere and the ocean.

The intimate connection between climate and local geographical conditions is everywhere apparent; nothing is more striking than the great differences between neighboring places where the effective local conditions are not alike, which often far surpass the contrasts attending the widest separation possible on the globe. Three or four miles of vertical height produce effects almost equal to those of transfer from the equator to the poles. The distribution of the great seas and continents gives rise to periodical winds—the trades and monsoons—which maintain their general characteristics over wide areas, but present almost infinite local modifications, whether of season, direction, or force. The direction of the coasts and their greater or less continuity greatly influence the flow of the currents of the ocean; and

these, with the periodical winds, tend on the one hand to equalize the temperature of the whole surface of the earth, and on the other to cause surprising variations within a limited area. Ranges of mountains, and their position in relation to the periodical or rain-bearing winds, are of primary importance in controlling the movements of the lower strata of the atmosphere, in which, owing to the laws of elastic gases, the great mass of the air and watery vapor are concentrated. By their presence they may either constitute a barrier across which no rain can pass, or determine the fall of torrents of rain around them. Their absence or their unfavorable position, by removing the causes of condensation, may lead to the neighboring tracts becoming rainless deserts.

The difficulties that arise, in accounting for the phenomena of climate on the earth as it now is, are naturally increased when the attempt is made to explain what is shown by geological evidence to have happened in past ages. The disposition has not been wanting to get over these last difficulties by invoking supposed changes in the sources of terrestrial heat, or in the conditions under which heat has been received by the earth, for which there is no justification in fact, in a manner similar to that in which violent departures from the observed course of Nature have been assumed to account for some of the analogous mechanical difficulties.

Among the most perplexing of such climatal problems are those involved in the former extension of glacial action of various sorts over areas which could hardly have been subject to it under existing terrestrial and solar conditions; and in the discovery, conversely, of indications of far higher temperatures at certain places than seems compatible with their high latitudes; and in the alternations of such extreme conditions. The true solution of these questions has apparently been found in the recognition of the disturbing effects of the varying eccentricity of the earth's orbit, which, though inappreciable in the comparatively few years to which the affairs of men are limited, become of great importance in the vastly increased period brought into consideration when dealing with the history of the earth. The changes of eccentricity of the orbit are not of a nature to cause appreciable differences in the mean temperature either of the earth generally or of the two hemispheres; but they may, when combined with changes of the direction of the earth's axis caused by the precession of the equinoxes and nutation, lead to exaggeration of the extremes of heat and cold, or to their diminution; and this would appear to supply the means of explaining the observed facts, though doubtless the detailed application of the conception will long continue to give rise to discussions. Mr. Croll, in his book entitled "Climate and Time," has recently brought together with much research all that can now be said on this subject; and the general correctness of that part of his conclusions which refers to the periodical occurrence of epochs

of greatly-increased winter cold and summer heat in one hemisphere, combined with a more equable climate in the other, appears to me to be fully established.

These are the considerations which are held to prove that the inorganic structure of the globe through all its successive stages—the earth beneath our feet, with its varied surface of land and sea, mountain and plain, and with its atmosphere which distributes heat and moisture over that surface—has been evolved as the necessary result of the original aggregation of matter at some extremely remote period, and of the subsequent modification of that matter in condition and form under the exclusive operation of invariable physical forces.

From these investigations we carry on the inquiry to the living creatures found upon the earth: what are their relations one to another, and what to the inorganic world with which they are associated?

This inquiry, first directed to the present time, and thence carried backward as far as possible into the past, proves that there is one general system of life, vegetable and animal, which is coextensive with the earth as it now is, and as it has been in all the successive stages of which we obtain a knowledge by geological research. The phenomena of life, as thus ascertained, are included in the organization of living creatures, and their distribution in time and place. The common bond that subsists between all vegetables and animals is testified by the identity of the ultimate elements of which they are composed. These elements are carbon, oxygen, hydrogen, and nitrogen, with a few others in comparatively small quantities; the whole of the materials of all living things being found among those that compose the inorganic portion of the earth.

The close relation existing between the least specialized animals and plants, and between these and organic matter not having life, and even with inorganic matter, is indicated by the difficulty that arises in determining the nature of the distinctions between them. Among the more highly-developed members of the two great branches of living creatures, the well-known similarities of structure observed in the various groups indicate a connection between proximate forms which was long seen to be akin to that derived through descent from a common ancestor by ordinary generation.

The facts of distribution show that certain forms are associated in certain areas, and that as we pass from one such area to another the forms of life change also. The general assemblages of living creatures in neighboring countries easily accessible to one another, and having similar climates, resemble one another; and much in the same way, as the distance between areas increases, or their mutual accessibility diminishes, or the conditions of climate differ, the likeness of the forms within them becomes continually less apparent.

The plants and animals existing at any time in any locality tend constantly to diffuse themselves around that local centre, this tendency being controlled by the conditions of climate, etc., of the surrounding area, so that under certain unfavorable conditions diffusion ceases.

The possibilities of life are further seen to be everywhere directly influenced by all external conditions, such as those of climate, including temperature, humidity, and wind; of the length of the seasons and days and nights; of the character of the surface, whether it be land or water; and whether it be covered by vegetation or otherwise; of the nature of the soil; of the presence of other living creatures, and many more. The abundance of forms of life in different areas (as distinguished from number of individuals) is also found to vary greatly, and to be related to the accessibility of such areas to immigration from without; to the existence, within or near the areas, of localities offering considerable variations of the conditions that chiefly affect life; and to the local climate and conditions being compatible with such immigration.

For the explanation of these and other phenomena of organization and distribution, the only direct evidence that observation can supply is that derived from the mode of propagation of creatures now living; and no other mode is known than that which takes place by ordinary generation, through descent from parent to offspring.

It was left for the genius of Darwin to point out how the course of Nature, as it now acts in the reproduction of living creatures, is sufficient for the interpretation of what had previously been incomprehensible in these matters. He showed how propagation by descent operates subject to the occurrence of certain small variations in the offspring, and that the preservation of some of these varieties to the exclusion of others follows as a necessary consequence when the external conditions are more suitable to the preserved forms than to those lost. The operation of these causes he called Natural Selection. Prolonged over a great extent of time, it supplies the long-sought key to the complex system of forms either now living on the earth, or the remains of which are found in the fossil state, and explains the relations among them, and the manner in which their distribution has taken place in time and space.

Thus we are brought to the conclusion that the directing forces which have been efficient in developing the existing forms of life from those which went before them are those same successive external conditions including both the forms of land and sea, and the character of the climate, which have already been shown to arise from the gradual modification of the material fabric of the globe as it slowly attained to its present state. In each succeeding epoch, and in each separate locality, the forms preserved and handed on to the future were determined by the general conditions of surface at the time and place; and the aggregate of successive sets of conditions over the

whole earth's surface has determined the entire series of forms which have existed in the past, and have survived till now.

As we recede from the present into the past, it necessarily follows, as a consequence of the ultimate failure of all evidence as to the conditions of the past, that positive testimony of the conformity of the facts with the principle of evolution gradually diminishes, and at length ceases. In the same way positive evidence of the continuity of action of all the physical forces of Nature eventually fails. But inasmuch as the evidence, so far as it can be procured, supports the belief in this continuity of action, and as we have no experience of the contrary being possible, the only justifiable conclusion is, that the production of life must have been going on as we now know it, without any intermission, from the time of its first appearance on the earth.

These considerations manifestly afford no sort of clew to the origin of life. They only serve to take us back to a very remote epoch, when the living creatures differed greatly in detail from those of the present time, but had such resemblances to them as to justify the conclusion that the essence of life then was the same as now; and through that epoch into an unknown anterior period, during which the possibility of life, as we understand it, began, and from which has emerged, in a way that we cannot comprehend, matter with its properties, bound together by what we call the elementary physical forces. There seems to be no foundation in any observed fact for suggesting that the wonderful property which we call life appertains to the combinations of elementary substances in association with which it is exclusively found, otherwise than as all other properties appertain to the particular forms or combinations of matter with which they are associated. It is no more possible to say how originated or operates the tendency of some sorts of matter to take the form of vapors, or fluids, or solid bodies, in all their various shapes, or for the various sorts of matter to attract one another or combine, than it is to explain the origin in certain forms of matter of the property we call life, or the mode of its action. For the present, at least, we must be content to accept such facts as the foundation of positive knowledge, and from them to rise to the apprehension of the means by which Nature has reached its present state, and is advancing into an unknown future.

These conceptions of the relations of animal and vegetable forms to the earth in its successive stages lead to views of the significance of type (i. e., the general system of structure running through various groups of organized beings) very different from those under which it was held to be an indication of some occult power directing the successive appearance of living creatures on the earth. In the light of evolution, type is nothing more than the direction given to the actual development of life by the forces that controlled the course of the successive generations leading from the past to the present. There

is no indication of any adherent or prearranged disposition toward the development of life in any particular direction. It would rather appear that the actual face of Nature is the result of a succession of apparently trivial incidents, which by some very slight alteration of local circumstances might often, it would seem, have been turned in a different direction. Some otherwise unimportant difference in the constitution or sequence of the substrata at any locality might have determined the elevation of mountains where a hollow filled by the sea was actually formed, and thereby the whole of the climatal and other conditions of a large area would have been changed, and an entirely different impulse given to the development of life locally, which might have impressed a new character on the whole face of Nature.

But further, all that we see or know to have existed upon the earth has been controlled to its most minute details by the original constitution of the matter which was drawn together to form our planet. The actual character of all inorganic substances, as of all living creatures, is only consistent with the actual constitution and proportions of the various substances of which the earth is composed. Other proportions than the actual ones in the constituents of the atmosphere would have required an entirely different organization in all air-breathing animals, and probably in all plants. With any considerable difference in the quantity of water either in the sea or distributed as vapor, vast changes in the constitution of living creatures must have been involved. Without oxygen, hydrogen, nitrogen, or carbon, what we term life would have been impossible. But such speculations need not be extended.

The substances of which the earth is now composed are identical with those of which it has always been made up; so far as is known it has lost nothing and has gained nothing, except what has been added in extremely minute quantities by the fall of meteorites. All that is or ever has been upon the earth is part of the earth, has sprung from the earth, is sustained by the earth, and returns to the earth; taking back thither what it withdrew, making good the materials on which life depends, without which it would cease, and which are destined again to enter into new forms, and contribute to the ever-onward flow of the great current of existence.

The progress of knowledge has removed all doubt as to the relation in which the human race stands to this great stream of life. It is now established that man existed on the earth at a period vastly anterior to any of which we have records in history or otherwise. He was the contemporary of many extinct mammalia at a time when the outlines of land and sea, and the conditions of climate over large parts of the earth, were wholly different from what they now are, and our race has been advancing toward its present condition during a series of ages for the extent of which ordinary conceptions of time

afford no suitable measure. These facts have, in recent years, given a different direction to opinion as to the manner in which the great groups of mankind have become distributed over the areas where they are now found; and difficulties once considered insuperable become soluble when regarded in connection with those great alterations of the outlines of land and sea which are shown to have been going on up to the very latest geographical periods. The ancient monuments of Egypt, which take us back perhaps seven thousand years from the present time, indicate that when they were erected the neighboring countries were in a condition of civilization not very greatly different from that which existed when they fell under the dominion of the Romans or Mohammedans hardly fifteen hundred years ago; and the progress of the population toward that condition can hardly be accounted for otherwise than by prolonged gradual transformations, going back to times so far distant as to require a geological rather than an historical standard of reckoning.

Man, in short, takes his place with the rest of the animate world, in the advancing front of which he occupies so conspicuous a position. Yet for this position he is indebted not to any exclusive powers of his own, but to the wonderful compelling forces of Nature which have lifted him, entirely without his knowledge, and almost without his participation, so far above the animals of whom he is still one, though the only one able to see or consider what he is.

For the social habits essential to his progress, which he possessed even in his most primitive state, man is without question dependent on his ancestors, as he is for his form and other physical peculiarities. In his advance to civilization he was insensibly forced, by the pressure of external circumstances, through the more savage condition, in which his life was that of the hunter, first to pastoral and then to agricultural occupations. The requirements of a population gradually increasing in numbers could only be met by a supply of food more regular and more abundant than could be provided by the chase. But the possibility of the change from the hunter to the shepherd or herdsman rested on the antecedent existence of animals suited to supply man with food, having gregarious habits, and fitted for domestication, such as sheep, goats, and horned cattle; for their support the social grasses were a necessary preliminary, and for the growth of these in sufficient abundance and naturally suitable for pasture was required. A further evasion of man's growing difficulty in obtaining sufficient food was secured by aid of the cereal grasses, which supplied the means by which agriculture, the outcome of pastoral life, became the chief occupation of more civilized generations. Lastly, when these increased facilities for providing food were in turn overtaken by the growth of the population, new power to cope with the recurring difficulty was gained through the cultivation of mechanical arts and of thought, for which the needful leisure was for the first time obtained

when the earliest steps of civilization had removed the necessity for unremitting search after the means of supporting existence. Then was broken down the chief barrier in the way of progress, and man was carried forward to the condition in which he now is.

It is impossible not to recognize that the growth of civilization, by aid of its instruments, pastoral and agricultural industry, was the result of the unconscious adoption of defenses supplied by what was exterior to man, rather than of any truly intelligent steps taken with forethought to attain it; and in these respects man, in his struggle for existence, has not differed from the humbler animals or from plants. Neither can the marvelous ultimate growth of his knowledge, and his acquisition of the power of applying to his use all that lies without him, be viewed as differing in any thing but form or degree from the earlier steps in his advance. The needful protection against the foes of his constantly-increasing race—the legions of hunger and disease, infinite in number, ever changing their mode of attack or springing up in new shapes—could only be attained by some fresh adaptation of his organization to his wants, and this has taken the form of that development of intellect which has placed all other creatures at his feet and all the powers of Nature in his hand.

The picture that I have thus attempted to draw presents to us our earth carrying with it, or receiving from the sun or other external bodies, as it travels through celestial space, all the materials and all the forces by help of which are fashioned whatever we see upon it. We may liken it to a great complex living organism, having an inert substratum of inorganic matter on which are formed many separate organized centres of life, but all bound up together by a common law of existence, each individual part depending on those around it, and on the past condition of the whole. Science is the study of the relations of the several parts of this organism one to another, and of the parts to the whole. It is the task of the geographer to bring together from all places on the earth's surface the materials from which shall be deduced the scientific conception of Nature. Geography supplies the rough blocks wherewith to build up that grand structure toward the completion of which science is striving. The traveler, who is the journeyman of science, collects from all quarters of the earth observations of fact, to be submitted to the research of the student, and to provide the necessary means of verifying the inductions obtained by study or the hypotheses suggested by it. If, therefore, travelers are to fulfill the duties put upon them by the division of scientific labor, they must maintain their knowledge of the several branches of science at such a standard as will enable them thoroughly to apprehend what are the present requirements of science, and the classes of fact on which fresh observation must be brought to bear to secure its advance. Nor does this involve any impracticable course of study. Such knowledge as will fit a traveler

for usefully participating in the progress of science is now placed within the reach of every one. The lustre of that energy and self-devotion which characterize the better class of explorers will not be dimmed by joining to it an amount of scientific training which will enable them to bring away from distant regions enlarged conceptions of other matters besides mere distance and direction. How great is the value to science of the observations of travelers endowed with a share of scientific instruction is testified by the labors of many living naturalists. In our days this is especially true; and I appeal to all who desire to promote the progress of geographical science as explorers, to prepare themselves for doing so efficiently, while they yet possess the vigor and physical powers that so much conduce to success in such pursuits.

## DIAMOND-CUTTING.[1]

By Dr. A. C. HAMLIN.

THE process of diamond-cutting is a very simple matter to those acquainted with the nature of the gem. To cut the facets, two stones are cemented on two sticks, and rubbed against each other until a facet is cut; then the position of one of the stones is changed, and another flat surface is cut. The process is thus continued until the gem is faceted all over. After the facets are cut, and a definite form given to the stone, the diamond is placed in the hands of the polisher, who fastens it in solder, and then holds it against a small steel disk revolving horizontally with a speed of 1,500 to 3,000 times a minute. This disk is moistened with oil mixed with diamond-powder, and one facet is polished at a time. Diamond-cutting proper is a rapid operation, but the polishing is slow and tedious. One cutter can generally furnish sufficient work for four or five polishers.

There are a number of forms adopted by the lapidaries for these gems, but the two principal ones are the brilliant and the rose. The former pattern, first practised in Europe in the seventeenth century, is by far the best adapted for calling forth the powers of the gem. The other form is of unknown antiquity, and has long been in use among the Hindoos. It affords the largest beams of light for the weight, but it lacks greatly in colored reflections when compared with the brilliant.

For the perfection of the rainbow-play of hues, it is essential that the facets of the superior and inferior parts of the stone should correspond in exact proportions, and stand at fixed distances, so as to multiply the reflections and refractions, and produce the colors of the

[1] From a work on "The Diamond," in the press of D. Appleton & Co.

prismatic spectrum. All limpid and white gems must be cut according to this rule, but with colored stones the case is different, for here perfection of color is to be attained, and brilliancy is a secondary consideration. Hence, a fine ruby or sapphire may be decidedly thin, and yet be a gem of great beauty and value.

FIG. 1.—STEWART DIAMOND. Rough South African Crystal, weight, 288⅜ carats.

FIG. 2.—STAR OF THE SOUTH. Rough weight, 254¼ carats.

The process of rifting diamonds by splitting them in their cleavage-planes was known long ago to the Hindoos, but was forgotten to modern lapidaries till revived by Wollaston not many years ago. By this means masses of the crystal may be removed to escape a flaw or remove a spot. Some diamonds of the spheroidal form are deficient

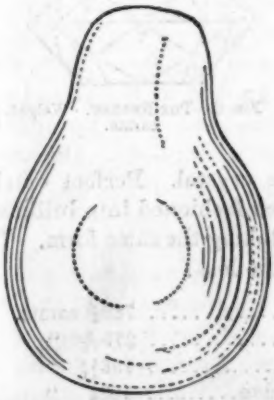

FIG. 3.—MATTAM DIAMOND, Borneo. Rough weight, 367 carats.

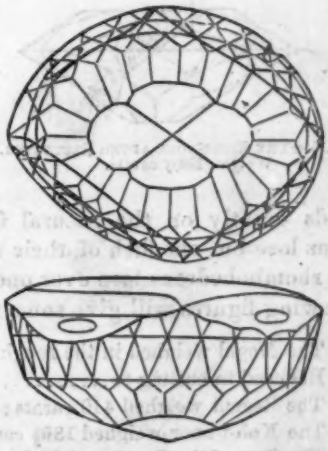

FIG. 4.—THE KOH-I-NOOR BEFORE RECUTTING.

in cleavage-planes, and are quite impracticable for cutting; others have a concentric arrangement of the planes of cleavage, as though crystallization radiated from the centre, and it is very difficult to polish them. The Hindoos avail themselves of the natural cleavage

of the gem, and form table diamonds by adroitly striking along one of the planes with a sharp-edged tool, thereby separating the layers, as slate is rifted by the miner. This operation, which appears so simple, really requires considerable skill, and much of that acquired instinct or tact which is best exhibited by our Western Indians, who chip, with marvelous rapidity and certainty, a glass-bottle into symmetrical arrow-heads.

The workman at a glance ascertains the direction of the laminæ, and with another diamond cuts a notch at the point where he would begin operations. In this notch he places the edge of his blunt steel knife, and, by tapping the back of it with a light iron rod, he splits the diamond with perfect ease. In reducing the natural diamond to a regular form, much of its substance is lost, and sometimes as much as one-half the weight of the stone. The amount of loss, however, de-

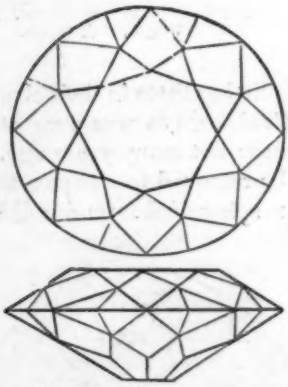

FIG. 5.—THE KOH-I-NOOR AFTER RECUTTING. Weight, 102⅛ carats.

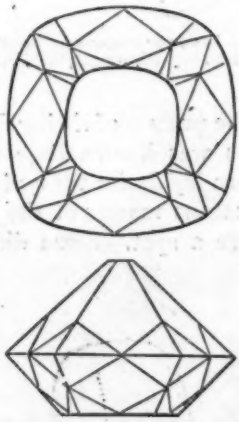

FIG. 6.—THE REGENT. Weight, 136 carats.

pends greatly on the natural form of the crystal. Perfect octahedrons lose but one-fifth of their weight when fashioned into brilliants, but rhombohedrons lose over one-third on taking the same form. The following figures will give some notion of the loss:

| | |
|---|---|
| The Mogul weighed in the rough | 780½ carats. |
| Reduced in cutting to | 279 9/16 " |
| The Regent weighed 410 carats; reduced to | 136 1/16 " |
| The Koh-i-noor weighed 186½ carats; reduced to | 102½ " |
| The Star of the South weighed 254½ carats; reduced to | 124 4/16 " |

The process of cutting diamonds of large size is always attended with risk, and is necessarily a costly operation. The Regent cost for cutting $25,000, and occupied two years' time. The Star of the South occupied only ninety days, and the Koh-i-noor only thirty-eight working-days. This great feat in diamond-cutting was performed by the

ablest of the Dutch lapidaries, with the aid of steam-power. The cost of cutting is said to have been $40,000—reduced, however, to some extent by the sale of the fragments.

The process of diamond-cutting has within a few years been established in the United States. Mr. Henry D. Morse, a jeweler of Boston, conceived the idea of constructing a machine for cutting and polishing the gem. While engaged in perfecting his appliances,

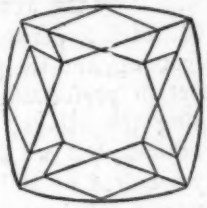

FIG. 7.—PROPER SIZE OF BRILLIANT DIAMOND, 100 CARATS, ACCORDING TO JEFFRIES'S SCALE.

FIG. 8.—FORM OF THE BRILLIANT-CUT.

chance threw in his way an itinerant vender of porcelain, who had once been employed as a workman in the diamond *ateliers* of Amsterdam. The sight of the rough gems and the apparatus recalled to the mind of the Jew the scenes of his youth, and awakened a desire to resume his former occupation, and he offered to do the work of a diamond-cutter. But, as the process was carefully considered, it was discovered that the Jew could only cut the facets of the diamond, and the art of the subsequent polishing he did not understand. It seemed strange that an artisan who possessed the rare ability to tell at a glance how large a gem the stone would cut, how to avoid internal imperfections, and how to take advantage of the cleavage-planes, could not polish the facets after he had cut them. But such was the fact, for the two processes of cutting and polishing are widely different, and require separate instruction. However, the deficiency was soon supplied by an acquaintance who was induced to leave Holland and act as polisher in the American diamond adventure. The establishment was now complete, but the business was at first confined to recutting and repolishing gems that had been damaged by long use or accident. The inventive genius of Mr. Morse made several important changes in the machinery required by the lapidary, and displaced the rude and cumbersome apparatus of the old system. At first but two or three men were employed, but, after the discovery of the South African diamond-mines, the rough gems soon furnished abundant material, and now several men and boys are constantly employed, with the aid of steam-power.

In consequence of the success of the South African diamonds, and the abundant supply of the stones, another *atelier* has been established in New York, under the direction of Mr. J. Hermann. A large amount

of capital is said to be invested in this adventure, and employment is given to forty or more workmen, all Israelites, with the aid of steam-power. The establishment already boasts of having cut a fine crystal from South Africa, weighing eighty carats.

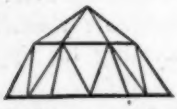

FIG. 9.—FORM OF THE ROSE-CUT.

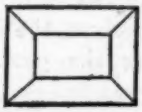

FIG. 10.—FORM OF THE TABLE-CUT.

The process of cutting the diamond is divided by the Jews into several distinct branches, and workmen are educated to perform one part but not another. Thus the cleaving, the cutting, and the polishing, have special operators, who become expert in performing well the parts assigned to them, without attempting the others. This course has undoubtedly produced skillful workmen, but we see no reason why all the parts may not be perfectly acquired by an intelligent mechanic. The art of cleavage, however, requires tact, and ought to include some knowledge of mineralogy. For the particulars of the art of diamond-cutting, we will refer our readers to the interesting works of Jeffries, Mawe, and Barbot; still we briefly mention here some of the forms adopted for the diamond, and how they are produced.

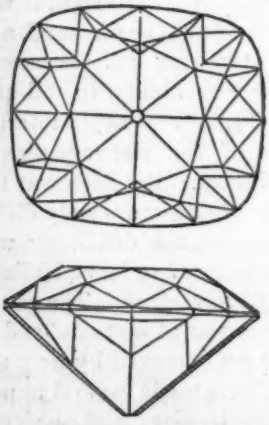

FIG. 11.—THE STAR OF THE SOUTH. Weight, 124¼ carats.

FIG. 12.—THE GREAT MOGUL. Weight, 279⅞ carats.

The table and the rose patterns were the first regular forms adopted by the lapidaries. The first was simply the top of the stone ground flat, with a corresponding flat bottom of less area, with its four upper and lower sides parallel to each other. As the light passed through the stone without much refraction, the beauty of the mineral was not developed by this pattern. It has been stated that the rose-shape was

invented in Paris, under the auspices of Cardinal Mazarin; but Tavernier describes the diamonds of Aurungzebe as being of the rose-cut. Therefore, we must give a more ancient date to the pattern than Mazarin's day. The form of the rose-cut is simply that of a hemisphere, covered with small facets. Its flattened base is therefore admirably adapted for incrustation-work, and the foil on which it is usually set serves as a reflector for the entering rays of light. The rose-pattern has several names, indicating the number of facets. If it has but twelve or less facets, it is called an Antwerp rose; if but eighteen or twenty, it is a semi-Holland; and a Holland rose, if it bears twenty-four facets. At the present time these gems are not in much demand, unless for incrustation-work, for which they are superior, both in effect and in adaptability to the surface of the object to be ornamented.

The form which appears to exhibit the splendors of the gem to the best advantage, is that known as the brilliant, and is rightly named from its effects. It was discovered in Italy, in the latter part of the seventeenth century, by Peruzzi, of Venice, which city was then one of the chief gem-marts of the world. The conclusions which led to the adoption of this shape were derived from experiments upon colored stones. This form of the brilliant is that of the ancient deep

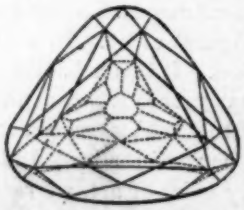

FIG. 13.—THE NASSACK. Weight, 78¾ carats.

table modified by receiving thirty-two facets above and twenty-four below its girdle. The great relative depth of the gem, aided by the numerous facets of the sides, appears to increase the natural refractive power of the stone by confining, as it were, the rays of light inside of it.

Another pattern, called the *brilliolette*, shows the beautiful qualities of the gem to great advantage. It is formed like two rose-diamonds joined together at the base; or may be flattened and elongated like an almond, and faceted all over with small facets. This is the form of the Sancy, and should have been given to the Koh-i-noor and the Star of the South. The Austrian yellow diamond is of this pattern, and was probably cut in India. And it is thought that the famous twelve Mazarin diamonds were also cut after this pattern. The star-pattern, which was invented by Cane, is but little used at the present time.

## READING AS AN INTELLECTUAL PROCESS.

By E. O. VAILE.

LANGUAGE possesses a double imperfection. It is incomplete as an expression, as a product, as a symbol; it is imperfect, also, as a cause, as an excitant. It is inadequate both to perfect expression and to perfect impression. It fails to receive fully all that the mind would put upon it, neither does it faithfully deliver all which it fairly received. The soul, struggle as it will, cannot embody itself in form. Expression cannot equal conception. Language suffers this imperfection in common with every plastic art. To the great master how feeble must have seemed his glorious "Ninth Symphony" as an expression of that heavenly harmony which must have filled his soul! What forms and colors, beyond the powers of matter to present, must have possessed the spirit which produced "The Last Judgment!" So with the great masters of literature. To how little of what they must have felt and thought have they been able to give a "local habitation and a name!" And then, even at our best, what a feeble hold do we lay upon what they have bequeathed!

Now, this full interpretation and appreciation of an author, the perfect work of the apparatus which should take the impression, constitute reading of the highest order. In such reading perception becomes intuition, divination. It is not baffled by the inherent weakness of language, but feels that "more is meant than meets the ear."

Of course, reading of this kind assumes, to a large extent, equality of mental stature in author and reader. Indeed, it is quite true that, from a book, as from any work of art, we receive that only which is a reflex of ourselves, the counterpart of what we are. Words and sentences do not receive their interpretation from the writer alone. The reader himself becomes an unconscious author, loading the vehicle according to his own calibre and character. It is even a question to what extent great authors "have built better than they knew," so ingenious and profound have been their commentators. Lowell says: "Goethe wrote his 'Faust' in its earliest form without a thought of the deeper meaning which the exposition of an age of criticism was to find in it; without foremeaning it he had impersonated in Mephistopheles the genius of his century." Some one has said: "No man is the wiser for his books until he is above them." Milton expresses the same in "Paradise Regained," b. iv., line 322:

> ". . . Who reads
> Incessantly, and to his reading brings not
> A spirit and judgment equal or superior,
> (And what he brings what need he elsewhere seek?)
> Uncertain and unsettled still remains,

> Deep versed in books, and shallow in himself,
> Crude or intoxicate, collecting toys,
> And trifles for choice matters, worth a sponge;
> As children gathering pebbles on the shore."

Notwithstanding their seeming inconsistency, these sentiments certainly contain a large portion of truth. It would be interesting to have the great poet's answer to his own parenthetical question. His devotion to books and his acquaintance with all literature and learning are a striking comment upon his query. Every *reader* must realize that the nearer his own intellectual grasp and sympathy coincide with his author's, the more nutriment he receives. Carlyle says, "We are all poets when we *read* a poem well."

In this reading well there is another element of very great importance, and exceedingly rare among ordinary people, not to speak of children. It is closely allied to the preceding. It is expressed in the phrase, "Reading between the lines." It is the perception of what is implied, as well as what is explicitly stated. It is the discovery, not of meanings purposely or carelessly hidden, but of thoughts which, in the highest symmetry and completeness, must have accompanied the one expressed. This power is needed in the proper reading of all good authors; but it is called forth most largely by our twin philosophers, Bacon and Shakespeare.

But there are elements more fundamental than these; so fundamental, in fact, that the thought seems seldom to occur to us that there can be any weakness in regard to them. The first of these, probably, is the knowledge of the meaning of words. How we obtain this knowledge is not so simple a question as it may seem.

We have a complete understanding of a term, when in our mind the association is so perfect between the arbitrary sign and the thing signified that the sign spontaneously suggests the thing. It is undoubtedly true that the first words addressed to a child are interpreted to him, and the idea fixed in his mind by the language of action and of circumstance which accompanies them. It is precisely the process by which a dog or a monkey is taught to perform its antics. The idea is associated directly with the phrase which strikes the ear, without a suspicion that there are any components, any words. The child's attention is engaged with complete propositions, and not with individual words; he grasps the whole, not realizing that there are parts. He hears you say, "Take care," "Come to mamma;" your actions and the circumstances associate the full thought with the proposition.

A process quite similar to this is employed by us largely through life. We get, and can get, the meaning of words to a great extent from their connections only. "Words are living things," says President Porter, "only when they are parts of the sentence. They cannot be fully understood except as seen in their connection." The power

to appreciate these connections, to feel their force, is a valuable acquisition, and one in which our youth are sadly deficient. It is a power, for want of which no amount of use of the dictionary will compensate; it is most requisite where the dictionary is not thought of, and should not be, in cases where common words are used with modified or figurative meanings. The intellect is not so robust under our modern methods, as when every boy ciphered for himself, and overcame his difficulties as best he could. The power to grasp another's thought seems to have deteriorated with the other faculties. Now every thing has to be explained. The ability to see through good English without the aid of commentary, tone and inflection, seems to be a lost art in our schools. Recently a large class in one of the best high-schools in the country showed itself to be entirely unable to comprehend such sentences as these: "Words are the counters of wise men; the coin of fools." "Worth makes the man; the want of it the fellow." In such cases nothing will avail but the perfect appreciation of the words from their connections. I would not encourage the habit of "jumping at the idea," but I would encourage the habit of digging it out by main strength. There is such a thing as wrestling with a thought until it seems to unfold itself to our comprehension: and he is not worth much as a reader who does not know by experience what it is to grapple with a passage, and to hold on to it until light breaks from within it. Our education tends to shield us entirely from such contests. We are taught to hasten to the quarto oracle. When it fails to respond, we give up in despair. We do not learn the use of native strength; too much assistance has shorn us of our locks.

Although there is this important duty to be performed quite independent of the dictionary, it by no means lessens the value of that book. Because it is the custom to dilute thoughts until their vigor is gone, and to explain text-books until no thought is required to comprehend them, it does not follow that explanation is never of use. The old adage is simply to be recalled: "A place for every thing, and every thing in its place." There is a place for explanations and for definitions; but there is a larger place for active thought, for strong, unaided wrestling with the printed page, for a keen appreciation of the connections of words.

There is no guarantee of thorough scholarship and character so sure as the proper use and appreciation of the dictionary. It is an infallible omen as to the future of any boy or girl. The right habit is acquired only painfully and slowly. It represents a most high and valuable degree of self-discipline, as well as of intellectual activity. Much more can be, and should be, done for it in our upper schools than is accomplished. Any course of training is defective from which pupils pass without that appreciation for the dictionary and that interest in it which they feel for a worthy teacher, full of knowledge, always accessible, and ever in the best humor.

Asking questions is not necessarily a good thing. There must be reflection and an active use of the senses accompanying every inquiry of any value to the querist. And so it is in looking for definitions. To do this impulsively, and to be satisfied with synonyms, is not effective work. The element of thought and of association is wanting. Meanings thus acquired do not become a permanent acquisition: whereas thorough effort seldom allows the necessity of referring to a definition a second time.

The power to read well is also in proportion to the development of the power of association. This is a faculty in which we differ very greatly, and yet it is largely a matter of education. To one person a statement in physics will stand unsupported, until common facts are brought to his notice, while to another instances in support will flock unbidden from the household or the wayside. To some minds, passages in one author will spontaneously suggest passages in another; while other minds will fail to perceive the relation until accident or design brings it directly to their notice. It is true that memory is a large factor in this matter; but, independent of this, there is a readiness of association which may be acquired, and which is very essential. It is a quickness to levy on our own observation and experience when another's ideas are presented. Bacon advises, "Read to weigh and consider." When we do this, association is the most prominent faculty at work. In fact, according to our strength in this faculty we will weigh and consider. An author's sentiment will be flanked, as it were, on both sides, by phenomena from our experience to support or attack him. The degree of this faculty distinguishes the strong from the weak; the teacher from the learner; culture from crudeness. It means digestion, assimilation. It is in this faculty that genuine learning differs from mere memorizing; thorough acquisition from cramming. It vivifies knowledge; it is almost wisdom. This faculty is quite subject to cultivation, and no acquisition will so well repay the labor expended upon it. The attention is not given to it in our education which should be. To childhood and youth the different subjects of study stand as unrelated wholes. There is no interchange of thoughts and associations between different branches. An idea occurring in one subject does not bring up a closely-related idea in another subject. Pupils are not taught nor led to connect their knowledges. It is so by the force of circumstances. Every class-room has its own presiding genius which fellowships with no other. Every specialist tends to reproduce himself. Furthermore, there is a feeble association between what is learned from books and what is learned from practice. Life in the school-room and life out of it are separate existences. In the popular notion, book-learning is a sort of mystery, a peculiar power quite distinct from the common-sense and common experience of every-day life. The "connection of the physical sciences" has become a familiar idea. When shall we realize that there is a connection be-

tween all sciences and all knowledge, and that one truth really becomes ours only in proportion as it is surrounded and illuminated by other truths already ours? But, in spite of all untoward circumstances, the power of association in reading can be, and should be, trained carefully.

The power to read well depends, likewise, upon our power of perception, of mental perception; upon the readiness with which we discover the relation between ideas. The degree of this faculty, more than any other one thing, constitutes the difference between dull and sharp minds. Also, it seems to be, more than any other faculty, a native endowment. However, training will show here as plainly as elsewhere. Persons blindfolded have described the contents of rooms, the position of doors, windows, etc., with such accuracy that the credulous have attributed to them a superhuman power; whereas, their whole secret lay in the development of their perceptive faculties. Circumstances unnoticed by others gave them information and the power of inference. The same difference may be observed among readers. One person at a single reading will grasp the thought precisely as it was expressed; for another, even time and study are not sufficient to impress all the modifications and the exact form of the idea. Our Federal Constitution affords a good opportunity to test this power of perception in reading. "No person except a natural-born citizen, or a citizen of the United States at the time of the adoption of this Constitution, shall be eligible to the office of President; neither shall any person be eligible to that office who shall not have attained to the age of thirty-five years, and been fourteen years a resident within the United States." Upon once perusing this, a fair reader would instantly recognize the difference between the two classes of citizens spoken of, and also *consciously* notice that in the last line it is not "citizen," but "resident," and he will distinctly perceive the difference in the meaning of these words. But this is just what a vast number of those who ought to be good readers will not do. They will not perceive these distinctions until study or comment brings them to their attention. I say a good reader will *consciously* perceive these differences; he will think of them as he goes along: for many persons will retain in a physical chamber of the mind, as it were, an echo of the words, and repeat them *verbatim*, but these distinct ideas will not penetrate their consciousness. Submit to the average readers of Byron this line upon the Gladiator:

> "... His manly brow
> Consents to death, but conquers agony,"

and judge of the quickness and clearness of their perception.

A large part of the function of this faculty consists in the perception of analogies. Such is its chief office for the student of literature The feeling of likeness in one way or another is the foundation of all

similes and metaphors, which make up so large a part of language. Here perception largely depends upon the power of reflection. Weakness often comes from neglect, or inability to hold the mind steadily to the thought. If you would be convinced of the general feebleness of perception of analogies and of their appreciation, experiment with a simple and beautiful couplet like this from Goldsmith:

> "To husband out life's taper at its close,
> And keep the flame from wasting by repose."

Or, this most perfect metaphor from Grattan on the failure of the Irish Government:

> "I sat by its cradle, I followed its hearse."

It is true that this power depends very largely upon maturity of mind and amount of experience. But it is the vigorous exercise of observation and perception, and not length of days, which gives maturity and experience.

Another faculty, and the foundation of all, upon which good reading depends, is the power of attention. Upon it directly depend the powers of association, of perception, and of memory. It is said that Sir Isaac Newton attributed his discoveries entirely to his habit of complete concentration of mind, and not to any superior quality of mind.

It is not a rare experience to most persons to find that they have read a passage, and yet that they are entirely unconscious of its contents. The physical man seems to have done its part perfectly; but the mind was employed upon other errands. Years are wasted before many of us discover that most of our ordinary reading is performed with not more than one-half of the mind, without real mental activity. There are persons who have been hard of hearing all their lives without realizing it, simply because experience has not given them an idea of a power more acute than their own. It is somewhat so in the matter of attention. It is rather a discovery to us when we first realize what may be accomplished by concentration of force; when we feel that attention is not passivity, but energy. It is a fortunate day for us when this awakening comes, and we begin the earnest endeavor to hold our mind to its work as though it were a truant school-boy.

We are told that we must appeal to curiosity to arouse this attention; that we must always read and study with interest. Good counsel, so far as it goes. But mere curiosity is quite inadequate to the great work of education. It may lead through "Nicholas Nickleby," but it rarely carries us through algebra or geometry. Something more reliable than a mere impulse is needed to make a strong mind. Back of all must stand a strong will, with the ability and disposition to use it. M. Marcel well says, "The great secret of education lies in exciting and directing the will." In later mental acquirements we realize the omnipotence of will. It is the want of this prime element

which makes our attention so weak in the period of immaturity. In childhood, attention is a direct product of curiosity. As we grow older, curiosity is sated, and becomes weak as a motor. Nothing takes its place until we discover that attention is under the control of the will, and until, by perseverance, we acquire the power of thus controlling it. It is only then that we make rapid conquests, and that genuine mental discipline shows itself. There is no reason why it should be so late in life before this force becomes a substitute, as it were, for curiosity. From want of this mastery of the will over attention, the great majority of our youth close their school-life without realizing of what they are really capable.

Instead of aiding to impart this power, ordinary school-work does positively the reverse. Humdrum repetition is made a substitute for attention. By dint of drilling and memorizing, recitations are prepared, but without concentration of thought. Our children simply mark time; they do not advance. They know of no means of acquisition but "study," in the school-room sense. To them it is not quality of effort, but quantity. They can appreciate exertion only in the bulk. They know little of intensity of labor, or of its rewards. To them simple reading means a very feeble, unsatisfactory hold upon the matter read. With the mind only thus half awake, comprehension of the author is very feeble; and, as a consequence, we find substantial, profitable reading a dull exercise to many who, by their training, as we think, ought to find pleasure in it.

It is to be observed that just in proportion to the intensity of our mental action in grappling the thought, just to that extent does the language vanish from our view, and the thought only remain. The mind is not conscious of having seen words, but only of having perceived ideas. Any one must realize, upon reflection, that, when studying with a purpose of verbal reproduction, there is a diversion of effort from the thought. Ordinary memorizing, instead of aiding, is the direct enemy of thought. As we are impressed by the peculiarities of language, the vigor of the sentiment loses. The best reader, so far as seeing the author's mind is concerned, is the poorest proof-reader in regard to mere typographical errors—attention to the vehicle is so much withdrawn from the content. Hence, that study or reading is not entirely worthless which fails to give us the power to reproduce. The power of expression generally lags behind the power of thought. The slightest observation of a child will convince that he often thinks and feels what he cannot declare. Unquestionably there may be good ground for the remark, "I know, but cannot tell." He is to be pitied who, even in mature years, never finds his soul pregnant with a thought, while he feels that the words adequate to convey it are wanting. There may be mental perception without the power to reflect it. This is a dangerous fact with which to allow children to become impressed, because of the universal proneness to find refuge

behind it from that wholesome effort at expression so essential to growth, and the clear apprehension of thought. For, without doubt, an idea is more firmly grasped and retained, and becomes negotiable only, by its clear enunciation. Generally speaking, "what we know, but cannot tell," is held by a very uncertain tenure. Thus, while the pupil should be urged to make his title good by the clear expression of his thought, he should realize that the most perfect reading fails to perceive the language consciously, or to retain it, leaving the thought disembodied, as it were, until the exigencies of communication require us to clothe it.

In connection with this matter of attention, the primary school affords abundant opportunity for remark. For instance, the habit of miscalling words. From what does it arise? Supposing the thought and language to be easily within the child's comprehension, it arises in this way: His attention has been exclusively occupied with individual words, in his struggle to master them He has failed to grasp the thought, or so much of the thought as he might have grasped up to the point of difficulty. Now, when circumstances bring the impulse to articulate a certain word, he is entirely unable to perceive whether or not the word coheres with what he has already uttered. In fact, he does not think, and cannot think, in regard to the sentiment of the sentence. His mind labors to recognize the words in their individual capacity only, and not at all in their connections. If he actually grasped the thought, although he might announce a word other than the one printed, still it would be impossible for him to announce a word which in the connection would be totally irrelevant or absurd. Now, in such a case, what is the teacher to do? To tell the child the word? To practically erase all the rest of the sentence, and to impress that individual form upon his mind? By no manner of means. This, however, is the universal practice; and from this practice partly results the abominable failure of our schools to teach our children to read fully and truly. It is the teacher's duty to get the child's mind on to the thought; to repeat the sentence, or to have it repeated, up to the point of difficulty, and to lead him by his own intellect to suggest a word, or the word, which will harmonize with the previous words. Indeed, he may not pronounce the word before his eyes, but, with any proper training, he will be far from suggesting a vocable which will present a solecism to his infantile perception. It is impossible to conceive of learning to read without miscalling words; but it is possible to conceive of a child's learning to read without pronouncing a word, among all his blunders, which his own powers are able to see is entirely absurd in the connection. Could that much be achieved, a great good would be done for us in after-life. One-half of the want of perception and attention which we now exhibit would be corrected.

Later in school-life teachers encounter this thing as a difficulty.

In "easy reading," children do not call the words printed, but others partly synonymous, or at least consistent. How is this to be looked at? It is a very trifling fault, so far as the real intellectual part of reading goes; the part we need in life, and which of all things should be taught. This fault, as it is called, is a good omen. You do not find the sluggards and the blockheads guilty of it. They continue the infantile fault first spoken of. This substitution of equivalent terms for those printed is done, and can be done, only by the bright, the active, the thoughtful. Observation will prove that this is invariably so. This fault teachers can well afford not only to tolerate, but to encourage. It indicates the presence of the only thing that is wanted—the clear grasping of the thought. It arises only because the pupil so fully comprehends that he is able by anticipation to supply a word for the author, if not *the* word. Such mistakes are worthy of remark, and, for the purpose of actually learning to read, there cannot be a better recitation than one made up entirely of such errors. Twenty reading-lessons devoted to this paraphrasing, and kindred work, to one of the ordinary kind of lessons, would work a wonderful change in the mental status of our children.

It is true, in the abstract, that words are the signs of ideas; but it is not true that the utterance of words by children is a sign that they possess the idea. We are taught in childhood upon the assumption that every sentence pronounced leaves its distinct and proper counterpart in our mind. None can know so well as teachers how far this is from being true; and how much more reliable as an indication of full mental perception, tone, inflection, emphasis, feature are, than the recital of the words. There is no fact which so loudly calls for the consideration of teachers as this—that the reading or reciting of words is a very uncertain sign that the idea is lodged in the child's mind. There is need for a new exercise and method in the teaching of reading; an exercise for teaching pure mental reading; a means of instruction in which things more reliable than words shall be taken as proof that the idea is grasped; a test of the accuracy of mental perception in which such unreliable evidence shall not be heard. There are devices which partly answer this purpose, but they cannot be described here.

If the real object to be aimed at in teaching reading were apprehended, there would be more use made of maxims, forms, riddles, etc. Every philosophic teacher must perceive their utility. They are of value only as a means of discipline; but there is nothing which so easily and strongly stimulates concentration of thought. They afford an opportunity to judge infallibly whether or not the learner clearly perceives. He is a rare child, indeed, who can read a pun, or any joke, to himself, and whose countenance will not promptly reveal to the slightest observation whether or not he "sees it." This cannot be said of ordinary sentences.

Furthermore, when wit does strike, it strikes with such effect, that the child himself cannot fail to discover whether he is hit or not; he cannot help but feel that he does or does not comprehend the idea. He may not be conscious that he does not clearly get an ordinary thought; but he can hardly remain so in regard to an epigram like this, upon a conceited person. He will either "see it," or know that he does not "see it:"

> "The best speculation the market holds forth
> To any enlightened lover of pelf,
> Is to buy Tommy up at the price he is worth,
> And sell him at that he puts on himself."

Or in regard to any of Lord Bacon's apothegms like this one. Dionysius gave no ear to the earnest suit of the philosopher Aristippus until the latter fell at the tyrant's feet. A by-stander afterward said to Aristippus, "You a philosopher, and to be so base as to throw yourself at the tyrant's feet to get a suit?" Aristippus answered, "The fault is not mine, but the fault is in Dionysius, who carries his ears in his feet."

What will so bring thought to a focus, and so develop the comprehension of words from their connections as a riddle like this from Dean Swift, and which Mr. Garvey, in his "Manual of Human Culture," mentions as an illustration upon this point:

> "From heaven I fell, though from earth I begin;
> No lady alive can show such a skin.
> I'm bright as an angel, and light as a feather,
> But heavy and dark when you squeeze me together.
> Though candor and truth in my aspect I bear,
> Yet many poor creatures I help to ensnare.
> Though so much of heaven appears in my make,
> The foulest impressions I easily take.
> My parent and I produce one another,
> The mother the daughter, and the daughter the mother."

Of course, such material, of which the active teacher will find abundance, must be used judiciously. The purpose must be to develop, not simply to entertain. Such specimens must be carefully adapted to the capacity of the class. Time must be given, and encouragement to "weigh and consider." Every contrast, comparison, and lurking sense, must be hunted out. No exercise in science or classics can equal this as a sharpener of the wits (to say nothing of wit). The child is made to realize what real comprehension is. He becomes familiar with the sensation which accompanies a clear perception, and is more sensitive to its absence when dealing with more ordinary thoughts. It is in this way that the study of Shakespeare, now being introduced into our high-schools, is going to do more for good common-sense in the comprehension and use of language, than all the

grammar taught in a century. It must be observed that a valuable part of the study of Shakespeare is of the same nature as this of which I have been treating. The study of the poet is largely a process of simply unfreighting words; an exercise in obtaining impressions from language under unfavorable circumstances, but with every thing to stimulate and reward the effort. We cannot find him lowered to the comprehension of young minds, as we can this scattered wit and wisdom, or he would be a perfect substitute for it.

It is pertinent to ask how we know, how we become certain, that we correctly conceive the idea of a word or a sentence. The only answer which can be given is, that our judgment seems to rely upon the general symmetry of the whole thought, a harmony of parts, a connection through and through which satisfies the mind that it is right. The judgment may err here as well as elsewhere. The accuracy of this mental perception depends wholly upon the general power and activity of the reader. The great thing is, that the reader should obtain a clear, consistent, and reasonable idea, taking into consideration all the circumstances and connections.

But there is a thing which education can invariably secure, and that is a ready consciousness that we do or do not obtain a clear, coherent idea from what we read. It would be unreasonable to demand that education should give us the power to understand all that we read; but it is perfectly reasonable to demand that it should give us the power to discriminate quickly between what we understand and what we do not understand; that it should develop that kind of attention which notifies us at once when we fail to get or comprehend clearly an author's thought. The failure here is one of the saddest features connected with the subject of reading, and, indeed, with the whole matter of common-school education. From the lowest grades to the highest our children read, learn, and recite passages, without comprehending them, and, what is far worse, without realizing their want of comprehension. Any close observer and questioner can satisfy himself of this by a short visit to the school of his own district. This is an unpardonable weakness in the methods of instruction. It is a shame, and there can be no defense for it. From every thing that he reads or learns, the child can, and should get, not necessarily a correct idea, but an idea intelligible and coherent according to his powers; or else he should be perfectly conscious that he gets no such idea.

It has become chronic with college presidents, professors, and examiners generally, to complain of the inability of our youth to speak and write the language. If these wise men were as wise as they ought to be, they would discover that they have not yet reached the fundamental evil. They must probe deeper if they would reach the bottom. The foundation of the trouble lies in the want of ability, or rather in the want of the habit of understanding language fully.

In spite of all our systematic education, there is a fearful lack of

accurate comprehension of good English; and this ever underlies the defect of expression. Of all the young men of whom the complaint is so justly made, I do not believe there is one to be found who has the faculties well developed which are necessary to a good reader. The primary fault is not to be found in the instruction in composition, but in the instruction in reading, and this last includes every subject in which the pupil has a book to use. Show me a person who is a good reader in the real sense of the term, one who has a strong power of attention, quick perception, active association, and other requisites to a fair mental reader, and I will show you a person who will not come far short of reasonable demands in his composition. The one follows the other naturally and invariably. This statement will be fully supported by any class after six months of faithful study of the English classics.

Of this want of comprehension there are several sources which are unwittingly fostered:

1. While children, we are compelled to study and read over and over again the same lessons. The mastery of words is made the end and the only end, in the view of both teacher and pupil, instead of remaining to each as a means only, a subordinate matter. Curiosity, at that age the natural governor of attention, is destroyed; and nine-tenths of our task-reading is performed with an indifference and weakness of thought which do not deserve the name of reading. This will continue so until the reading-matter put into our schools is greatly increased in variety and amount. Rarely, and only at long intervals, should a lesson be read more than once. The habit of seeming to read, of performing the physical part, while the mental faculties lie as dead, is easily formed. But it should be resisted. The problem before the primary teacher is this: To keep firmly fixed in the child's mind that the chief thing is the idea, while at the same time he is duly impressed with forms and words. Not only must the tongue utter, but the spirit must *see* what we read.

2. Also, in childhood we are allowed or required to read what we do not understand. A common illustration of one form of this evil occurred recently in the closing exercises of a first-class normal school. The pupil-teacher was to exhibit her power by means of a lesson in writing to a large class of bright boys about seven years of age. She had placed upon the black-board, as her copy, those four familiar lines—

> "Work while you work,
> Play while you play," etc.

The writing was certainly most admirable; but the inquiries of the lady-principal revealed the fact that the children had not the least conception of the first two lines. Most, indeed, seemed not to have thought any thing about the meaning. This is a sample, taken, however, from normal training, of the vast number of ways in which as

children we are permitted or required to handle words without associating any meaning with them. The same may be seen in the thoughtless singing of our Sabbath-schools. Thus words become the only things which we think of; and we lose the feelings which accompany clear comprehension, or the want of comprehension. Accustomed to a dull tool, we lose the consciousness that it is dull. But let us rarely have a dull one in our hands, and how intolerable it seems to work with it! Blunt our keen perceptions upon things which we do not or cannot penetrate, and we become insensible to the fact that our instrument is dull, and fails to perform its proper work. It is better, by all means, that the child should attach wrong ideas to all he reads, than that he should form the habit of reading without attaching any ideas. Let any friend of education look upon the stolidity of the average product of our schools, which comes from this mechanical, absolutely thoughtless reading, and he cannot but feel that we are producing a large amount of artificial stupidity. I do not say that pupils should *never* be required to read or learn what they do not comprehend; but I do say that such should never be the requisition so long as they are in danger of falling into the habit of which I speak, nor until they have the habit of reading with the distinct realization that they do comprehend or that they do not.

3. I have said that the power of expression is possible only after a proper development of the capacity to receive impressions. The power and the habit of conveying thought will follow as a consequence of, and in proportion to, the power and the habit of receiving thought. This plainly indicates the plan which should be adopted by any rational system of primary instruction in reading. As a matter of fact, however, the universal practice of teachers is in direct opposition to this principle. It is assumed on all hands that the practice of reading can have no other object than to impart elocutionary skill; to cultivate the power of oral expression. The great question which governs the method in this branch is not, Do we understand others? but, How to make others understand us. It is taken for granted that distinctness of articulation, correctness of inflection, etc., surely indicate the presence of the thought within. Pupils are drilled almost daily in reading from the time they are six until they are sixteen, and yet they cannot read. They pass over that which to them is intelligible and that which is not intelligible alike, without the least discrimination. Words, words merely, are their only currency. Professors of elocution, and teachers of reading, do not impart the power we need. They teach us an accomplishment, but neglect our necessity. They make oral reading a high and important end, while it is simply a means, and should so be used. Our children are taught as though a large portion of their existence were to be spent in reading aloud; whereas, probably not one-fiftieth of all the reading done by people in ordinary circumstances is of that kind. For most of us, it is our intellectual busi-

ness in life to understand, to receive, to unload, as it were, that which others have put aboard. At least ability in this line is what we need infinitely more than the mere art of conveying thought. The number is comparatively small of those who are called upon to create, to body forth the soul either as orators or writers. The truth is, within the proper and legitimate sphere of school-reading, the cultivation of the organs of speech should be strictly subordinate to the great end of acquiring and retaining thoughts. The voice and ear have just that kind of work to do, and no other, which is performed by the gauge upon the steam-boiler, viz., to afford a means of judging of the condition of things within—the one of the pressure of steam, the other of the clearness and coherence of ideas. The paramount object in learning to read is to acquire the power of obtaining from the printed page, and by means of the eye only, ideas clearly and quickly. This should be the foremost thing with every teacher. Tone, emphasis, inflection, and general expression are, or should be, only the test-marks to indicate to the teacher whether or not the thought as presented by the printed words is fairly lodged in the mind of the learner. This perfectly subsidiary character of oral reading and the actual comprehension of the thought are almost entirely lost sight of. The subject is taught as a fine art, an art of expression only, the same as music, instead of the art of soul-perceptions, the art of seeing and feeling ideas and sentiments.

Such are some of the faculties which need attention in making good readers, and some existing faults which need correction.

## THE DEEPER HARMONIES OF SCIENCE AND RELIGION.[1]

### IV.

AT the outset I drew a distinction between theology and religion. Theology I considered to be the intellectual or scientific knowledge of God, religion the imaginative or sympathetic knowledge of him. After examining, then, to what extent theology is modified by the omission of the supernatural source of knowledge, after showing that it is in no way destroyed, since it has always been of the essence of theology to inquire what is the relation of the universe to human ideals—and this inquiry remains legitimate, necessary, and all-important, whether we appeal to natural or supernatural evidence—I pass on to consider the modification produced by the same omission in religion. With what *feelings* should we regard God contemplated only in Nature?

It will be evident, from what was said at the close of the last chapter, that the common impressions about the worship of Nature are

[1] From a series of papers, in *Macmillan's Magazine*, on "Natural Religion."

quite mistaken. It is vaguely imagined that the worship of Nature is neither more nor less than classical paganism, and that to adopt it would be to revive the "golden years" Shelley sings of, to substitute a *Madre Natura* for the Christian Church, and Pan or Apollo for Christ. This is a misconception of precisely the same sort as that which regards Nature as pitiless and inhuman. Let us always remember that Nature, as we are using that most ambiguous of words, is opposed simply to the supernatural. Sometimes, as I pointed out, it is opposed to man. When paganism is said to be a worship of Nature, the word is used in a third sense, and one somewhat indeterminate. It is opposed rather to civilization. Paganism did not confine itself to the worship of inanimate Nature. It deified, to be sure, the sun and moon, the sky, the morning and evening star, and all the principal phenomena of inanimate Nature. But it worshiped also certain deities who were supposed to preside over human life, powers of birth, marriage, and death, protectors of tribes and cities, powers of war and commerce, powers of the human mind. When we call it Nature-worship, therefore, we are not using the word Nature simply as opposed to man. But it so happened, we may say quite accidentally, that in its worship of the phenomena of man paganism paused abruptly. The worshiping disposition in the ancient nations decayed as society advanced; they ceased to increase their Pantheon as human phenomena became known to them. The consequence is, that the deities that have to do with human life in paganism concern only what is most elementary and primitive in human life. To people in the tribal stage paganism would have seemed to embrace the whole of humanity as well as inanimate Nature. But when nations had left that stage far behind them, when they had devised complicated politics, and invented arts and sciences, paganism still remained in its old condition. It did not progress, and in the last ages of the ancient world the traditional religions reflected the image of a much simpler time. This in reality deprived them of all influence except with the rural population, but at the same time it gave them a charm to all those who were influenced by that reaction against civilization and progress which is always going on. The same charm is felt by us when we look back upon paganism. When we see statues of Pan or Faunus, when we read Homer, we feel the fascination of *naïveté* and simplicity. And to express what we feel we fall back upon the unfortunate and overworked word Nature. We say these old pagans worshiped Nature, meaning apparently to say that their thoughts and feelings had not been much modified by the influence of thinkers, inventors, systematizers, that in fact their minds were in a childlike state, and had the freshness and joyousness of childhood.

Evidently Nature here is not in any way opposed to the supernatural. The supernatural could not enter into any creed more than it entered into the creeds of these so-called worshipers of Nature.

And, if the supernatural were omitted from our present creeds, the residuum would not be classical paganism. It would be something like what paganism would have been if religious feeling had not been weakened by the growing complication of human life. Had men's minds continued as religious in the age of Aristotle as they were in the days of Homer, it is not difficult to see how paganism would have developed. The great product of civilization is the development in men's minds of the feeling of justice, duty, and self-sacrifice. These new feelings, then, would have embodied themselves in new deities, or new conceptions of old ones. Paganism in developing would have become moral, and so would have lost all the charm which the moderns, tired of morality, find in it. And in doing so it would not necessarily have given more weight to the supernatural, and might easily have given less. Notions of duty and morality have no necessary connection with the supernatural. The worship of God in Nature, therefore, the worship of the Being revealed to us by science, would not be a religion without morality, because, however science may repudiate the supernatural, it cannot repudiate the law of duty. To human beings that have reached a certain social stage, duty is a thing quite as real as the sun and stars, and exciting much deeper feelings. In the sense in which we are using the word, duty is a part of Nature. The worship of Nature, therefore, would be no paganism. It would not be mere animal happiness, or æsthetic enjoyment of beauty. It would be far more like Christianity. It would be mainly concerned with questions of right and wrong; it would be in almost as much danger as Christianity of running into excesses of introspection and asceticism.

But, now that we are on our guard against this misconception, let us go somewhat further back to inquire what the religion of God in Nature will be. The word religion is commonly and conveniently appropriated to the feelings with which we regard God. But those feelings—love, awe, admiration, which together make up religion—are felt in various combinations for human beings, and even for inanimate objects. It is not exclusively but only *par excellence* that religion is directed toward God. When feelings of admiration are very strong, they find vent in some act; when they are strong and at the same time serious and permanent, they express themselves in recurring acts, and hence arise ritual and liturgy, and whatever the multitude identifies with religion. But, without ritual, religion may exist in its elementary state, and this elementary state of religion is what may be described as *habitual and permanent admiration.*

Religious feeling readily connects itself with the supernatural—"Gern wohnt er unter Feen, Talismanen"[1]—but, at the same time, religious feeling can restrain itself, and sometimes even deliberately chooses to restrain itself from all associations of the kind. Accord-

[1] Loves to dwell amid fairies and talismans.

ingly, whatever the principal object of religious feeling in a particular case may be, of that object there springs up a natural religion and also a supernatural religion. There have been two classes of religions which have been conspicuous by their difference in the history of mankind. On the one hand, there have been the religions which have found their objects of worship principally in the sensible world, in physical phenomena, and in man considered as a physical phenomenon. On the other hand, there are the religions which contemplate more what is intellectual and moral. The best example of the former class is classical paganism, which, as I pointed out, was arrested in its development at the moment when it began to embrace the moral world; to the other class belong Judaism and Christianity. Now, both these forms of religion may be found connected with the supernatural and also unconnected with it. Classical paganism itself was a supernatural religion. The feelings excited in the Greek by the sight of a tree or a fountain did not end where they began, in admiration, delight, and love; they passed on into miracle. The natural phenomenon was transformed into a marvelous quasi-human being. But the same feelings aroused in the mind of Wordsworth produced a new religion of Nature not less real or intense than that of the ancients, but unconnected with the supernatural. He worships trees and fountains and flowers for themselves and as they are; if his imagination at times plays with them, he does not mistake the play for earnest. The daisy, after all, is a *flower*, and it is as a flower that he likes best to worship it. "Let good men feel the soul of Nature and see things as they are." In like manner moral religion has taken two forms. Judaism and Christianity are to a certain extent supernatural religions, but rationalistic forms of both have sprung up in which it has been attempted to preserve the religious principle which is at the bottom of them, discarding the supernatural element with which it is mixed. The worship of humanity, which has been springing up in Europe since the middle of the last century, is in a like manner a religion of moral qualities divorced from the supernatural.

If religion really accepts the supernatural even when its object is only isolated physical phenomena or human beings, how much more so when its object is God, whether God be regarded as the Cause of the universe or as the universe itself considered as a unity! Our experience of a limited physical phenomenon may be some measure of its powers; the antecedent improbability of its transcending in a particular case the limit which our experience had led us to put upon our conception of it may be very great. But who can place any limits to Nature or to the universe? We may indeed require rigid proof of whatever transcends our experience, but it is not only Orientals who say that "with God all things are possible;" the most scientific men are the most willing to admit that our experience is no measure of Nature, and that it is mere ignorance to pronounce *a priori* any

thing to be impossible. Accordingly, those religions which have had for their object the unity of the universe, or what we call, *par excellence*, God, as distinguished from gods many and lords many, have generally been most lavish of miracle. They have delighted to believe in whatever is most improbable, because by doing so they seemed to show how strongly they realized the greatness of their Divinity. *Credo quia impossibile* is a paradox specially belonging to the religion of God. But, on the other hand, there is nothing in this religion that requires the miraculous. Those who realize the infinity and eternity of Nature most, and who are most prepared to admit that nothing is impossible, may quite well believe at the same time that the laws of Nature are invariable, and may be as skeptical as the most narrow-minded slaves of experience about particular stories of miracle that come before them. Indeed, there is perceptible, both in Judaism and Christianity, along with the fullest and readiest belief in miracle, a certain contempt for those who attach much importance to such occasional exceptions to general law. Prophets and apostles and Christ himself believe one and all that God can and does, at his pleasure, suspend ordinary laws; they believe this as a matter of course, and with a kind of wonder that any one can doubt it; but they hold it rather as a matter of course than as a matter of much importance—though they may hold a particular suspension of law to be very important for the light it throws on the Divine will; and it is evident that the God of their worship is rather the God who habitually maintains his laws than the God who occasionally suspends them. As therefore we found that the physical religion which in paganism existed along with a belief in the supernatural appeared elsewhere divorced from it, and that the Christian religion of humanity reappeared in modern religions divorced from miracle, so we may expect to find somewhere a purely natural religion of God.

I have before asserted that modern science, however contemptuously it may reject the supernatural, has nevertheless both a theology and a God. It has a God because it believes in an Infinite and Eternal Being; it has a theology because it believes in the urgent necessity of obeying his laws and in the happiness that comes from doing so. Is it not equally true that it has or may have a religion? If religion be made of love, awe and admiration, is not Nature a proper object of these as well as of scientific study?

It will be said that the religion of God thus understood is intelligible enough, but has no character of its own by which it may be differenced from the physical and moral religions described above. When we admire a flower we are worshiping Nature, but this is paganism stripped of the supernatural, or Wordsworthianism. When we admire justice or self-sacrifice in any human being, we are again, after the explanation given above, worshiping Nature, but this is Christianity stripped of the supernatural, or the modern religion of

humanity. Now, what third kind of religion can there be unless we introduce a third or supernatural order of beings? I answer that the natural religion of God, though closely connected with both of these religions, is nevertheless clearly distinct from them. Its material is certainly the same; it contemplates the same phenomena and no others, but it contemplates them in a different spirit and for a different purpose. The object which excites its admiration may be, as in the former case, a tree, a flower, the sky, or the sea, but the admiration, when aroused, goes beyond the object which aroused it, and fixes upon a great unity, more or less strongly realized, in which all things cohere. It is thus that the view which the man of science takes of any natural object differs from that taken by an uneducated man. The admiration of the latter is, as it were, pagan. It ends in the particular form and color before it. It sees nothing in the object but the object itself. But the eye of science passes entirely beyond the object and sees the law that works in it; instead of the individual it sees the kind, and beyond the kind it sees higher unities in endless scale. What it admires is also in a sense Nature, but it is not Nature as a collective name for natural things, but Nature as the unity of natural things, or, in other words, God. Similar, with feelings less distinct but probably stronger, is the contemplation of Nature in ancient Hebrew poetry, which, when it surveys the great phenomena of the world, instead of considering each by itself in succession, instinctively collects them under a transcendent unity. Instead of saying, "How spacious the floor of ocean, how stately the march of the clouds across heaven, how winged the flight of the wind!" the Hebrew poet says, "*Who* layeth the beams of his chambers in the waters, *who* maketh the clouds his chariot, and walketh upon the wings of the wind."

We see, then, that human admiration, when it organizes itself in religion, may take three forms and not two only. Not only may it fix itself almost exclusively upon sensible phenomena and become paganism, or turn away from the sensible world to contemplate moral qualities as in Christianity, but also it may fix itself not upon the phenomena themselves, but upon a unity of them. The simplest form of this religion of unity is, I suppose, Mohammedanism, which not only contemplates a unity of the world, but takes scarcely any interest in the phenomena themselves, the unity of which it contemplates. Lost in the idea of the greatness of God, it loses its interest in the visible evidences of his greatness; but in most cases this religion of unity is combined with one or both of the other religions. The unity worshiped is not an abstract unity, but a unity either of the physical or of the moral world, or of both. In paganism the physical world is not worshiped simply for itself, but a feeble attempt is made to establish some unity among its phenomena by setting up a supreme Jove over the multitude of deities. In the moral religions the tendency to

unity is still stronger, so much so that it may seem wrong to class, as we have done, Judaism and Christianity among religions of humanity rather than religions of God. They are, in fact, both at once, and the former at least is primarily a religion of God, and only secondarily a religion of humanity. It is because the worship of humanity in them, rather than the worship of Deity, determines their specific character, because they conceive Deity itself as a transcendent humanity, or as united with humanity; it is not because Deity plays a less, but because humanity plays a *more* prominent part in them, that I have chosen to name them rather from humanity than from Deity.

When, therefore, modern systematizers, in endeavoring to organize a religion which should exclude the supernatural, have extracted out of Christianity a religion of humanity, and have rejected as obsolete whatever in it had relation to Deity, they have not been wrong in taking what they have taken, though wrong in leaving what they have left. Deity is found in other religions besides Christianity, and in some religions, e. g., in Islamism, is not a whit less prominent than in Christianity; what is characteristic of the Christian system is its worship of humanity. How great a mistake, nevertheless, is made when it is supposed that Deity ought to be removed out of our religious systems, or that the rejection of supernaturalism in any way involves the dethronement of Deity or the transference to any other object of the unique devotion due to him, I shall show immediately; but what I have said about those inferior forms of religion which have not God for their object suggests another observation before we pass to consider the religion of God.

## SKETCH OF PRINCIPAL DAWSON.

JOHN WILLIAM DAWSON was born at Pictou, Nova Scotia, in 1820. He received his early academic training in the College of Pictou. Here, in addition to the regular course of study, he investigated with great success the natural history of his native province, thus early manifesting a taste for original scientific inquiry.

Having finished his course at Pictou, he entered the University of Edinburgh. After a winter's study he returned to Nova Scotia, and devoted himself with ardor to geological research. He was the companion of Sir Charles Lyell during his tour in Nova Scotia, in 1842.

In the autumn of 1846 he returned to the University of Edinburgh, his special objects of study being now practical chemistry and other subjects, of which he had found the necessity in the original work in which he was engaged.

In 1850 he was appointed Superintendent of Education for Nova Scotia. This office he held for three years, and rendered valuable ser-

vice to that province at a time of special interest in the history of its schools and educational institutions. He also took an active part in the establishment of a normal school in Nova Scotia, and in the regulation of the affairs of the University of New Brunswick, as a member of the commission appointed by Sir Edmund Head for the purpose.

In 1855 he was called to the position which he still holds, that of Principal and Professor of Natural History in McGill College and University, an institution which, situated in Montreal, the commercial capital of Canada, draws its students from all parts of the Dominion. The university has prospered under his wise and liberal management beyond the most sanguine expectations of its friends and promoters.

The raising of McGill College to its present position would have been work enough in itself for these years, but in addition to this Dr. Dawson has had under his care the Protestant Normal School. From his position there he has had a great deal to do with the moulding and controlling of the school system of the country. After many years' faithful work, he withdrew (in 1870) from this office.

His special work in connection with the university and the normal school took up much of that time which would have otherwise have been devoted to original investigations in his favorite science.

A review of his more important scientific labors will show us how much may be done even in the midst of engrossing educational occupations. As early as 1830 Dr. Dawson began to make collections of the fossil plants of the Nova Scotia coal formation. In 1841 he contributed to the Wernerian Society of Edinburgh his first scientific paper, on the species of field-mice found in Nova Scotia. In 1843 he communicated a paper on the rocks of Eastern Nova Scotia to the Geological Society of London; this was followed in 1844 by a paper on the newer coal formation. In 1845, besides exploring and reporting on the iron-mines of Londonderry, Nova Scotia, he published a paper on the coal fossils of that province.

During the winter of 1846–'47, while studying in Edinburgh, he contributed to the Royal Society of that city papers on the "Formation of Gypsum," and on the "Bowlder Formation," and an article to Jameson's *Edinburgh Philosophical Journal*, on the "Renewal of Forests destroyed by Fire." The facts embodied in the last were subsequently employed by him in combating the exaggerated periods of time assigned to such changes by European geologists.

From 1847 to 1849 we find him, with the same never-flagging zeal, pursuing his geological researches, and giving the results to the world in frequent papers. The most important of these are: 1. "On the Triassic Red Sandstones of Nova Scotia and Prince Edward Island;" 2. "On the Coloring Matters of Red Sandstones;" 3. "On Erect Calamites found near Pictou;" 4. "On the Metamorphic Rocks of Nova Scotia." He also published his "Handbook of the Geography and Natural History of Nova Scotia," and delivered courses of

lectures on natural history and geology in the Pictou Academy, and in Dalhousie College, Halifax, and reported to the Nova Scotia Government on the coal-fields of Southern Cape Breton.

In 1852, in company with Sir Charles Lyell, he made a reëxamination of the Joggins section, and visited the remarkable deposit of Albertite at Hillsborough, New Brunswick. A paper soon appeared on the Joggins section, giving a more full exposition than any previous one of the structure and mode of formation of a coal-field. The Albert Mine was also made the subject of a paper. In the further study of the Joggins section, microscopic examinations were made of coal from all its beds, as well as of coal from other sources, the results being published in papers on the "Structures in Coal," and on the "Mode of Accumulation of Coal."

It was during the visit to the Joggins, just referred to, that the remains of *Dendrerpeton Acadianum* and *Pupa vetusta* were found. With the exception of *Baphetes planiceps*, which Dr. Dawson had discovered the year previous at Pictou, but not described, *Dendrerpeton Acadianum* was the first reptile found in the coal formation of America, while *Pupa vetusta* was the first known Palæozoic land-snail. These discoveries were followed by the finding and describing of several other reptiles, and of the first carboniferous millipede (*Xylobius sigillariæ*). About this time, also, a second report on the Acadia mines was prepared, and an elaborate series of assays of coal made for the General Mining Association.

In 1855 he published the first edition of his "Acadian Geology." In 1856, though now trammeled by the arduous duties incumbent upon the principal of a university, he still continued his geological work in his native province, and prepared a description of the Silurian and Devonian rocks. During the same summer he visited Lake Superior, and wrote a paper and report on the copper-regions of Mamainse and Georgian Bay.

In the two following years he made a number of contributions to the *Canadian Naturalist* and the *Journal of the Geological Society*, and commenced the study of the Post-pliocene deposits of Canada. In 1859 his "Archaia," or studies of creation in Genesis, appeared, a work showing not only a thorough knowledge of natural history, but also considerable familiarity with the Hebrew language.

In 1860 Dr. Dawson issued a supplementary chapter to his "Acadian Geology." He also continued his work in fossil botany, and in the Post-pliocene, publishing several papers on these subjects, as well as desultory researches on such subjects as the "Flora of Mount Washington," "Indian Antiquities at Montreal," "Marine Animals of the St. Lawrence," "Earthquakes in Canada," "Classification of Animals," etc.

In 1863 he issued his "Air-Breathers of the Coal Formation," a complete account of the fossil reptiles and other land animals of the

coal of Nova Scotia. This publication was followed, in 1864, by a "Handbook of Scientific Agriculture." It was in 1864, moreover, that Dr. Dawson made what may be considered as one of the most important of his scientific discoveries—that of *Eozoon Canadense*. Previous to this the rocks of the Laurentian age were looked upon as devoid of animal remains, and called "Azoic."

In 1865 Dr. Dawson, at the meeting of the British Association at Birmingham, gave illustrations of his researches on the "Succession of Palæozoic Floras," the "Post-pliocene of Canada," and the "Structure of Eozoon."

While in England, in 1870, Dr. Dawson lectured at the Royal Institution. He also read a paper on the "Affinities of Coal Plants" before the Geological Society, and one on the "Devonian Flora" before the Royal Society. The same year his "Handbook of Canadian Zoölogy" appeared, being followed in 1871 by a "Report on the Silurian and Devonian Flora of Canada," and a "Report on the Geological Structure of Prince Edward Island." His studies of the Devonian plants were begun as early as 1858, and Gaspé, St. John's, and Perry in Maine, were twice visited in order to collect material to aid in their pursuance.

His "Notes on the Post-pliocene of Canada" were published in 1873. From them we learn that the number of known species of Post-pliocene fossils had been raised principally by his labors from about thirty to over two hundred. We also find that Dr. Dawson is still what he has always been, a stanch opponent to the theory of general land glaciation. "The Story of the Earth and Man," issued last year, was a republication of papers published in the *Leisure Hour* in 1871 and 1872. A report on the "Fossil Flora of the Lower Carboniferous Coal Measures of Canada," and communications to the British Geological Society on the probable Permian age of beds overlying the coal-measures of Nova Scotia, and also occurring in Prince Edward Island, and on recent facts as to the mode of occurrence of Eozoon in the Laurentian rocks, are still more recent labors. A course of six lectures delivered in New York in the winter of 1874–'75 has been largely circulated both in America and England, under the title "Science and the Bible;" and last fall there appeared in London and New York a popular illustrated *résumé* of the facts relating to Eozoon and other ancient fossils, entitled "The Dawn of Life." At the Detroit meeting of the American Association, Prof. Dawson, as Vice-President of Section B, delivered an address in which he vigorously combated the doctrine of evolution.

Dr. Dawson was elected a Fellow of the Geological Society of London in 1854, and of the Royal Society in 1862. He is a Master of Arts of Edinburgh, and Doctor of Laws of McGill; and is an honorary or corresponding member of many of the scientific societies on both sides of the Atlantic.

# EDITOR'S TABLE.

### THE NATION ON "GERMAN DARWINISM."

SOME months ago a correspondent asked the *Nation* what were the best books to read on the theory of evolution. It replied, and seized the occasion to draw a contrast unfavorable to Herbert Spencer, whose books on that subject, it took pains to say, it did *not* recommend. In a more recent review of two books under the title of "German Darwinism," the same writer came forward and reaffirmed the positions of the former article, amplified the discussion, and continued to refer to Mr. Spencer in terms of contemptuous disparagement. More recently, in a eulogistic sketch of the character of the late Chauncey Wright, of Cambridge, the *Nation* recognizes him as the "great mind" of the town, and informs us that he was the author of the article on "German Darwinism." This was no news to many. A few years ago it was quietly given out from Cambridge that the pretensions of Mr. Spencer were to be once for all disposed of by Chauncey Wright, who would do the work in the *North American Review*. The onslaught was made, but, from divers indications, both at home and abroad, it seems to have failed of its intended effect. But Mr. Wright appears to have regarded it as his permanent function to put down this philosopher, and accordingly the last literary act of his life was another attempt to demolish him. It looks almost like a Cambridge fashion for its great men to die in their antipathies. The article on "German Darwinism," from its misleading character and its appearance in the *Nation*, was entitled to an answer; but this is still more necessary, now that its authorship is announced in connection with very high claims put forth for the author. It is still further provocative of reply, as, upon careful perusal, it will be found to throw very little light indeed upon "German Darwinism;" that topic being used mainly as a convenient means of reviving and repointing the writer's old charges against Spencer. We have no desire to pursue this topic; but, as long as such charges are conspicuously and authoritatively made, they must be answered.

Referring first to the most trivial, it is insinuated that the system of Mr. Spencer has a footing with "English-thinking readers" only; while in fact various of his works are translated into Italian, German, Hungarian, Dutch, Russian, and French, and nearly all of them into the latter languages. Several of the translations, moreover, have been made by eminent philosophical scholars, and it is fairly to be presumed that their continued reproduction in foreign countries is due to a demand for them.

In noticing Schmidt's German work on "Darwinism and Descent," the writer makes a point against Mr. Spencer by stating that he is nowhere named in it. Gegenbaur had done the same thing in his great work on "Comparative Anatomy," and he was reproached by Prof. Rolleston in the *Academy* for giving no account of Spencer's "Biology," which made his work defective. There are various reasons why the Germans have been slow to recognize Mr. Spencer's ideas. They are embodied in a "system of philosophy," and by philosophy the Germans understand only speculations like those of Kant, Hegel, and Schelling. They have no conception of a philosophy organized out of science, and their biologists do not dream of finding the development

of species scientifically dealt with in a philosophical system. Understanding philosophy as the Germans do, and being wedded to their *a priori* system, they have habitually sneered at "English philosophy," and therefore pay little attention to its new books. Again, they are greatly given to titles of all orders, political, social, scientific. Every man is jealous of his distinctions—they glory in their "jewels five words long," as they have been called. Hence they think nothing of a man without scientific titles, and it is beyond their imagination that any one should refuse them. Mr. Spencer was, therefore, without due passports to German consideration. But against the fact that Schmidt has ignored him, we may put the fact that the translation of "First Principles" into German was made at the instigation of Darwin's chief German disciple, Haeckel, and was made by his assistant, Dr. Vetter.

Mr. Darwin is made out to be untheological by an exquisite bit of logic. It is true that he appeals to supernaturalism for the starting-point of his doctrine, and gives exactly the same account of it that theology has always offered, speaking of "life with its several powers having been originally breathed by the Creator into a few forms, or into one." But Mr. Darwin's science is saved by the charitable imputation that he used these words in a sort of Pickwickian or poetical sense, and was willing to conciliate the theologians by "a slight difference of style" in referring to the origin of life. But when to an extensive series of expository works, treating of the course of Nature by rigorous scientific method, Mr. Spencer prefixes an essay of a hundred and odd pages, to clear away religious difficulties and protect himself from the imputation of materialism, which was sure to be made against his scientific labors, there is neither kindly feeling to see the propriety of such a course, nor even a sense of justice to recognize the fact; but the whole system is declared to be theological in origin and character, because, forsooth, the author put theology aside at the outset of his undertaking.

We here touch upon the main source of misunderstanding of Mr. Spencer's system. The preliminary part which treats of religion is necessarily metaphysical. But Mr. Spencer does not regard religion as an illusion, nor metaphysics as necessarily futile. He holds that the order of the universe is not without its cause, although the nature of that cause is a mystery past finding out, and from the very nature of intelligence must forever transcend the human understanding. The infinite source of things is usually called God, and there are many who hold that man can have a knowledge of God as of other things; Mr. Spencer declines to use the current term; and, to mark his own sense of humility toward that infinite cause or power of which all phenomena are manifestations, he prefers employing the term The Unknowable. What is represented by it is not a negation or a nothing, but the most exalted object of religious feeling, though beyond the grasp and analysis of intellect. Having defined his ground in this preliminary dissertation, and shown that science deals with the phenomenal, while religion relates to that which transcends the phenomenal, so that there can be no radical or fundamental conflict between them, he then proceeds to his great work of organizing the highest and most certain knowledge attainable of the phenomenal universe into a system of philosophy. That system must be judged intrinsically, or on its own merits, as a coherent and consistent body of demonstrable and verifiable truth; yet his critics, from unscrupulous motives—resenting his assumption in undertaking so immense a task, or from incapacity—getting swamped among the factors of a great discussion, have a habit of rep-

resenting him as basing his philosophical system on metaphysical speculations regarding the Unknowable, and as the author of an unknowable philosophy. The article on "German Darwinism" rings many changes on this gross misrepresentation.

The writer says that evolution is regarded by Darwin "as a theorem of natural history," while Mr. Spencer treats of evolution "as a philosophical thesis deductively, and as a part of a system of metaphysics;" and furthermore, "a system like Mr. Spencer's is obliged to stand on such positions," namely, "undemonstrated beliefs." Again, he says, "Evolution is, with Mr. Spencer, not a theorem of inductive science, but a necessary truth deduced from axioms." These statements—is it not almost needless to say it?—are altogether groundless. Mr. Spencer's system never could have taken the hold of the cultivated scientific mind of half a dozen nations in the present age, which it confessedly has, if the above characterization of it were true. Speaking of an important research of Mr. Spencer, the President of the Royal Society of London, when addressing the British Association, said: "I need dwell no further on it here than to quote it as an example of what may be done by an acute observer and experimentalist, versed in physics and chemistry, but above all thoroughly instructed in scientific methods." Testimony like this, that Mr. Spencer, whatever may be his shortcomings, is a master of scientific methods, might be accumulated to any extent. Is it probable or conceivable that a man so thoroughly equipped for their use should repudiate the sound and solid methods of science, and fly off into baseless speculation when dealing with the most comprehensive and important scientific problem of our time? The thing is absurd unless it is proved, and the author of "German Darwinism" stops with mere dogmatic assertion.

We aver, on the other hand, that the scope of Mr. Spencer's great argument for evolution is only equaled by the fidelity and completeness of his adherence throughout to the established canons of scientific inquiry, and his reputation as a master of true logical method is beyond doubt mainly due to his practical application of it in the construction of his system. In "First Principles" the law of evolution is placed upon the most comprehensive inductive basis; and, if we go back to the earlier enunciation of his views, we find the law propounded with no reference whatever to metaphysical speculations. The original form of the conception and the order of its development are seen in the essay on "Progress, its Law and Cause." There is here not a word of metaphysics, not a word implying the endeavor to derive the phenomena from the persistence of force, not a shadow of foundation for the alleged theologico-metaphysical origin of the doctrine. The first part of the essay is devoted entirely to establishing the induction, from all orders of phenomena, that every thing progresses in heterogeneity; and then, the induction having been established as universal, the second part of the essay is an inquiry into the dynamical law which determines it in all cases. This second part sets out thus: "And now from this uniformity of procedure may we not infer some fundamental necessity whence it results? May we not rationally seek for some all-pervading process of things? Does not the universality of the *law* imply a universal *cause?*" And then the course of the argument is, first, to show that the cause alleged, the multiplication of effects, affords a deductive interpretation of the induction previously established. Are we to be told that this is an illegitimate scientific procedure?

The author of "German Darwinism" pronounces Spencer unscientific and unbaconian, because he employs the deductive or *a priori* method. But

is not that the method in which science finds its completion? Did it weaken the induction made by Mr. Spencer, to show that the facts are deducible from a general law in the redistributions of matter and motion? Was the induction made by Kepler respecting the laws of planetary motion weakened when Newton proved those laws to be deducible from the law of gravitation? If so, then truths are scientific only so long as they remain empirical generalizations, and become unscientific when they are reduced to the form of rational generalizations. In pursuance of this view we may say that, so long as the geometrical truth, that the square of the hypothenuse of a right-angled triangle is equal to the squares of the other two sides, is recognized as experimentally true, it constitutes a part of real science, but that it becomes metaphysical and worthless when it is shown to follow inevitably from necessary axioms and postulates. The strictures of the author of "German Darwinism," leveled at Spencer as an *a priori* thinker, thus spend their force against completeness of scientific method. The reproach cast upon him could have had no possible ground, if in elucidating the law of evolution Mr. Spencer had left it in the form of a generalization based upon all orders of phenomena—astronomical, geological, biological, psychological, and sociological—that is, if he had left the work half done. But when the law is explained, or when the universal course of transformation is shown to result from certain universal laws of physical action—laws which are themselves inductively established before they are deductively applied—then Mr. Spencer is to be discredited as a mere speculating metaphysician. It is now admitted as a principle—a universal principle—that force can neither come out of nothing nor disappear into nothing. It is "conserved," say some physicists; it "persists," says Mr. Spencer, and its persistence is an ultimate truth. The laws of physical action which result in evolution, undeniable as they severally are, are shown by Mr. Spencer to be all corollaries from this ultimate truth. They are established by induction, they are explained and verified by proving that they are consequences of a universal principle; therefore Mr. Spencer is metaphysical and unscientific.

The *Nation* declares that "there is nothing in Spencer's writing relating to what is really honored by men of science (namely, the scientific explanation of the origin of species) that is not to be credited either to Lamarck or Darwin." Lamarck is to be credited with the sagacious perception, and the courageous avowal, in opposition to Cuvier and the whole science of his time, of the doctrine of the variability of species, and the thinness of the partition between species and varieties. He saw many facts that led him to deny the Cuverian dogma of the fixity of species, and he had a strong conviction that their variation was in some way connected with surrounding conditions. That is, Lamarck has the great merit of having perceived the nature of the biological problem that was yet to be solved, but he can hardly be said to have entered upon its solution. Mr. Darwin is to be credited with the sagacious working out of one of the conditions of that problem, namely, the influence of natural selection in giving rise to the diversities of species. But the achievements of both Lamarck and Darwin only bring us to the threshold of the great general question of which they form a part. If their positions are held to be valid, they simply open the door to a new and immense scientific investigation which has for its object to determine the conditions, processes, and causes of evolution. That natural selection is not evolution, but only one of its elements, and that Mr. Darwin has never engaged in the investigation of evolution in its general principles as Science is bound to consider it,

we have shown again and again in these pages. Mr. Spencer, therefore, undertook no illegitimate or superfluous task in devoting many years to evolutionary researches. If the work of Darwin and other biologists was not futile, the larger inquiry was imminent and lay straight in the path of progressive science. Mr. Spencer undertook it, and the language of the *Nation* implies that in his contributions to it there is nothing that is really honored by men of science. To this dictum we give a flat contradiction, and, if space allowed, we could weary our readers with the copious evidence that eminent men of science honor the work of Spencer by accepting his results as guides to their own investigations. Let one illustration suffice: Mr. Alfred Russel Wallace, one of the independent discoverers of the principle of natural selection, in his address as President of the Anthropological Society of London, in 1872, referred to a view propounded by Mr. Spencer on biological evolution as "one of the most ingenious and remarkable theories ever put forth on a question of natural history." Nor did he stop with turning a mere compliment. He went on to say: "More than six years ago Mr. Herbert Spencer published, in his 'Principles of Biology,' a view of the nature and origin of the Annulose type of animals, which goes to the very root of the whole question; and, if this view is a sound one, it must so materially affect the interpretation of all embryological and anatomical facts bearing on this great subject, that those who work in ignorance of it can hardly hope to arrive at true results. I propose, therefore, to lay before you a brief sketch of Mr. Spencer's theory, with the hope of calling attention to it and inducing some of you to take up what seems to me a most promising line of research." Of course there are plenty of scientific men who do not honor what Mr. Spencer has done and care little for what anybody has done outside of his own narrow specialties. Human nature works in scientific men, it must be confessed, much as it does in other people, and they often exhibit petty jealousies toward each other that are a scandal to the scientific character. That from timidity, prejudice, and lack of interest in general ideas, many of them should decline to honor a broad and independent thinker like Spencer, is not surprising. But all scientific men are not of this class.

We again affirm that the task which Mr. Spencer accepted, of investigating the general principles of evolution, was one that stood clearly in the pathway of Science, and was not to be escaped. He was the first to grasp the full breadth of its implications, the first to analyze it into its elements, the first to organize its varied facts into a coherent system, and make it the basis of a comprehensive philosophy of Nature. His "First Principles," containing the full exposition of the doctrine, has now been before the world thirteen years, and its essential positions have not yet been impugned. There has not been even an attempt to invalidate his proofs that the processes of universal change are from the homogeneous to the heterogeneous. There has never been even an attempt to invalidate his universal principle of the "Instability of the Homogeneous." There has not been even an attempt to invalidate the principle of the "Multiplication of Effects;" nor have his critics ever even tried to show that these great principles are not essential and fundamental factors of evolution; and until this is done they may as well hold their peace in regard to his claims as an original explorer in this field.

Finally, in his zeal to upset Spencer, the *Nation's* writer throws Bacon at his head, but he sadly misses his aim. It is now well understood that Bacon's attempt to lay down the rules of scientific pursuit was a signal failure. He tried his own rules in the investigation

of heat, without discovering any thing about it; he was grossly inappreciative of the science and scientific men of his day, rejecting the Copernican system, and neglecting the immortal researches of Harvey. It will hardly be believed that the *Nation's* critic quotes against Spencer one of the most unfortunate passages that Bacon ever wrote: that in which he condemns the chemists of his day for philosophizing "from a few experiments of the furnace;" and disparages the work of the celebrated founder of the science of magnetism, Dr. Gilbert. Mr. Spencer can very well afford to be condemned with such company. Whatever weight, indeed, Bacon has as a philosopher must go into the other side of the scale. If he failed as a scientist, or in laying down the special rules of research, he did great service in calling men away from scholastic verbalism, and inciting them to the study of Nature; while there can be no doubt that he had great insight for comprehensive relations, and saw with the eye of prophetic genius the coming day when human knowledge would be so perfected and marshaled as to represent the unity and continuity of Nature. When Bacon is appealed to against Spencer, we say that if he had lived in our day, with the ripened sciences at command, it is not unlikely that he might have written "First Principles." At all events, if his eminent German interpreter, Dr. Hans Fischer, is to be trusted, his mind ran very much in the same direction of thought. In his work, "Francis Bacon of Verulam," Dr. Fischer says: "What in Bacon's sense is the proposed Fundamental Philosophy (*Philosophia Prima*)? The unity of all the sciences. Bacon seeks this unity by the method of analogy. Not on dialectical but on real grounds should the universal predicates of things (such as much and little, like and different, possible and impossible, essential and contingent, etc.) be determined." Again: "The very design of Bacon's analogies shows that he sought more than can be afforded by experience. He sought by this road what he could not discover by that of induction alone, namely, the unity of Nature as manifested in the affinity of all things, or the harmony of the universe."

## LITERARY NOTICES.

ANNUAL REPORT OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION, showing the Operations, Expenditures, and Condition of the Institution for the Year 1874. Washington: Government Printing-Office, 1875. Pp. 416.

WE had occasion in the October number of THE POPULAR SCIENCE MONTHLY to notice the last report of the Astronomer Royal of England, and to remark upon the great persistency with which "the fundamental idea" of the Royal Observatory had been followed out for forty years, and the great success which had attended its work.

We have a no less remarkable instance of the intelligent, careful, and devoted following out of a well-considered plan and of great success, in the case of our own Smithsonian Institution, under the direction of Prof. Henry and his most efficient seconders and collaborators. The Smithsonian Institution was founded by James Smithson of England, "for the increase and diffusion of knowledge among men." In the first annual report of the secretary (Prof. Henry), for 1846, a definite "plan of organization" was proposed, which has been adequate to all the conditions which then existed and which have since arisen.

It proposed in brief: "To INCREASE KNOWLEDGE: 1. To stimulate men of talent to make original researches, by offering suitable rewards for memoirs containing new truths; and, 2. To appropriate annually a portion of the income for particular researches, under the direction of suitable persons. To DIFFUSE KNOWLEDGE: 1. To publish a series of periodical reports on the progress of the different branches of knowledge; and, 2. To publish occasionally separate treatises on subjects of general interest." This plan has been devotedly carried out, and we propose to extract from Prof. Henry's report for 1874 enough to

show in part how important and useful the work of the institution is, and how large a field it covers.

In direct compliance with the programme above given, the institution publishes three classes of works: *first*, the "Contributions to Knowledge" (quarto), which are memoirs "containing some positive addition to science resting on original research, and which are generally the result of investigations to which the institution has, in some way, rendered assistance;" *second*, the "Miscellaneous Collections" (octavo), which consist of works "intended to facilitate the study of branches of natural history, meteorology, etc., and are designed especially to induce individuals to engage in these studies as specialties;" *third*, the "Annual Reports" (octavo) contain, besides the accounts of the operations, expenditures, etc., "translations from works not generally accessible to American students, reports of lectures, abstracts of correspondence, etc." These are liberally distributed free of cost to public libraries, institutions, colleges, States, and Territories, in such a way, and under such conditions, as shall secure them to be most generally accessible and useful. No copyright has ever been secured on any of the publications of the Institution. They are left perfectly free to be used by the compilers of books and all other persons, on the express condition that due credit is to be given, not only to the author of the book, but to the Smithsonian Institution. This is eminently just, because in most cases the researches have been prosecuted with the aid of funds from the Smithson bequest. The publications for 1874 have been Volume XIX. of the "Contributions to Knowledge," which contains the results of three most important researches: 1. On Problems of Rotary Motion, by General J. G. Barnard, pp. 74. 2. On Fresh-water Algæ, by Prof. H. C. Wood, pp. 274, 21 colored plates. 3. Orbit and Tables of Uranus, by Prof. S. Newcomb, pp. 296.

Besides this, the eleventh and twelfth volumes of the "Miscellaneous Collections" have been issued, containing nine contributions: On the Families of Mammals and Fishes, by Dr. Theodore Gill; On the Diptera of North America, by H. Loew; Directions for collecting and preserving Insects, by Dr. Packard; two papers on Coleoptera, by Dr. John Le Conte; Review of American Birds, by Prof. Baird; On the Constants of Nature, Part I., boiling-points, specific gravities, etc., by Prof. Clarke (noticed in THE POPULAR SCIENCE MONTHLY, August, 1874); and Rules for the Telegraphic Announcement of Astronomical Discoveries, by Prof. Henry. Several of the separate memoirs which will make up Volume XX. of the "Contributions to Knowledge" have already been printed and distributed: 1. On the General Integrals of Planetary Motion, by Prof. Newcomb; 2. On the Haidah Indians of Queen Charlotte Islands, by James G. Swan. At the time of making the report, there were *in the press*, and intended for the quarto publications: 1. The Antiquities of Tennessee, by Dr. Joseph Jones; 2. The Harmonies of the Solar System, by Prof. S. Alexander (noticed in THE POPULAR SCIENCE MONTHLY for September, 1875); 3. The Winds of the Globe, by the late Prof. J. H. Coffin; 4. The Temperature-Tables of North America, by C. A. Schott. There were also *in the press* a monograph of American Wasps, by Prof. de Saussure, of Geneva, and a botanical index to all known American species of plants.

For many years the Smithsonian Institution had a large corps of volunteer meteorological observers distributed all over the United States, who forwarded their reports for discussion to Washington. These observers have been transferred to the United States Signal Bureau of the War Department, to whom their reports are now furnished. But an immense amount of valuable meteorological material has accumulated at the Smithsonian Institution, which is to be discussed and published. The first work of this series, on "Rainfall," has already been printed, the discussion of the observations having been done by Prof. Schott, of the Coast Survey. The second volume, on the "Winds of the Globe," by Prof. J. H. Coffin, and continued by his son and by Dr. Woeikof, will be published in 1875. The next work of the series treats of the "Temperature of the United States," and will also be published during this year. It deals with all available observations of

temperature in the United States from the earliest times to the present: these have been discussed by Prof. Schott, aided by computers paid from the Smithson fund. Still another work of this series is in progress on the "Geographical Distribution of Thunder-Storms," and another work will soon be commenced on the deductions from barometrical observations in the United States.

The Institution is also aiding in a research on the orbit of the periodic comet of Tuttle (time of revolution thirteen years), prosecuted under the direction of Prof. Stone. An investigation into the efficiency of steam-heaters has been aided by the Institution during the year.

"The *diffusion* of knowledge among men" is powerfully aided by the Smithsonian system of exchanges. The Institution is in correspondence with more than two thousand institutions, whose publications, etc., it distributes in this country, and to whom it forwards works relating to scientific and literary advances in America. As is said by the secretary in his report, "the effect of this system on the diffusion of knowledge cannot be too highly estimated." The exchanges in books and pamphlets alone amount to 5,546 in 1874, and these are deposited in the Library of Congress, where they are available for research. The telegraphic announcements of astronomical discoveries in Europe and America have been in operation since 1873, and are of the highest benefit to astronomical science. *Six* asteroids and *six* comets were so announced in 1874.

The National Museum is deposited in the building of the Institution, and is under the care of Prof. Baird, Assistant Secretary. Constant additions are yearly made to it from all parts of the world, and all sources are laid under contribution. Mr. P. T. Barnum gives to the institution all animals which die in his menagerie, and Mr. Blackford, of Fulton Market, New York City, selects, from the thousands of fish which come weekly into his hands, all rare and curious ones, which are at once sent in ice to the museum. There is, indeed, no part of the globe from which contributions are not received. All the War Department and other surveys in the West, the Navy Department surveys and exploring expeditions, the State Department Boundary Survey, and many other collectors, deposit the results of their work here, where they are discussed and elaborated. The museum furnishes also, from its duplicates, specimens for study to specialists who desire them. Its collections of insects, etc., are deposited with the Department of Agriculture, and exchanges are constantly kept up with this and other institutions. The United States Fish Commission may be almost considered as a part of the Institution; the valuable results which have already accrued from its scientific and energetic labors are too well known to need more than a mention.

The secretary of the Institution has for twenty years been a member of the Light-house Board, and is now its chairman, and to this connection Science owes the extensive series of experiments on sound in its relation to fog-signals, which are published in the appendix to the light-house report for 1874. The results from these experiments will undoubtedly be a guide for all governments in their choice of a method of fog-signaling.

Besides the valuable report of the secretary, of which the above is an abstract, there are given: Eulogies on Laplace, Quetelet, and De la Rive, by Arago, Mailly, and Dumas; a lecture on Tides and Tidal Action in Harbors, by Prof. Hilgard; Observations of Atmospheric Electricity and Aurora, by Lemström; an essay on a Dominant Language for Science, by De Candolle; Underground Temperature, by Schott and Everett; The North Carolina Earthquakes, by Du Pre and Henry; Warming and Ventilation, by Morin; and several short communications on Ethnology. All of these translations and memoirs are interesting and valuable, and many of them deserve a special review, but we must be content to notice how carefully they are selected to aid in the diffusion of information not generally accessible.

Enough has been given to show that the closing words of the secretary's report are but a mere statement of present facts: "The Institution is successfully prosecuting the plan adopted for realizing the benevolent intention of its founder, in the way of increasing and diffusing knowledge

among men; its funds are again in a prosperous condition, and its reputation and usefulness are still on the increase."

The adoption of a wise and well-considered plan and a steady adherence to "the fundamental idea" have resulted in this instance, as they will result in all, in lasting and permanent good and in brilliant success. Perhaps the most valuable lesson to be derived from the present report is in its unwritten precepts, which show how a scientific trust may be administered so as to produce the greatest return to the world, and at the same time to preserve for science the full benefit of the endowment. There is no country where these lessons deserve more careful study than in our own, and we are fortunate in having in our midst an example of good administration based on wise prevision, and guided by high scientific intelligence.

BACTERIA AND THEIR INFLUENCE UPON THE ORIGIN AND DEVELOPMENT OF SEPTIC COMPLICATIONS OF WOUNDS. By L. A. STIMSON, M. D. Wood Prize Essay of the Alumni Association of Bellevue Hospital Medical College. 34 pages. New York: D. Appleton & Co., 1875.

IN the early pages of this pamphlet the author explains what is meant by the terms *bacterium* and *vibrio*, gives the various classifications that have been proposed for them, and then goes into an account of their natural history, including structure, development, motions, nourishment, functions, and distribution. Briefly summed up, "Bacteria are microscopical vegetable organisms of two main varieties: 1. Round or oval cells 0.0005—0.0010 mm. in diameter, single or arranged in lines or groups. . . . 2. Cylindrical cells, 0.002—0.003 mm. long, single or arranged in lines. . . . There is no genetic relationship between them and ordinary mould and fungus. They are found in the air, water, and most animal and vegetable tissues. They are *saprophytes*, not *parasites*, and are unable in themselves to cause infectious diseases." The remainder of the essay is on the second branch of the subject, viz., what these organisms have to do with the origin and development of the putrid conditions of wounds, and on the treatment to be adopted for the prevention or relief of such conditions.

FIRE-BURIAL AMONG OUR GERMANIC FOREFATHERS. By KARL BLIND. London: Longmans, Green & Co. 24 pp.

THE author shows that fire-burial was once the ruling custom with the Germanic races, and thinks it not strange that the German people should so readily accept the views of Sir Henry Thompson on cremation. Their occasional torchlight processions at night in honor of departed princes are lingering relics of fire-burial.

The Saxons and Frisians of old were terrified at the dark, narrow grave when the change was made from burning to burial. With the Northmen, cremation succeeded mound-burial. In Gaul, Cæsar observed that the natives practised cremation, and Tacitus mentions fire-burial as a Germanic custom, special kinds of wood being set apart for chieftains.

The dog of the Norse warrior was burnt with him. Horses, too, were burned, and in some countries the custom of leading his horse after the coffin of a chief still prevails.

"We burn the corpses of those we love," said a Norseman in the tenth century to an Arab embassador, "but you bury in the earth where vermin and worms devour."

The Northmen buried the ashes after cremation, and planted flowers over the tomb. These practices have found expression in many poems and legends of the races where they prevailed, and the author is exceedingly happy in pressing them into service in his historical notice.

REPORT OF THE CURATORS OF THE MISSOURI STATE UNIVERSITY FOR THE YEAR ENDING JUNE, 1875. Pp. 208.

FROM this Report we learn that during the past year the Curators purchased, as a *locale* for the School of Mines, the public school-building in the town of Rolla, at a cost of $25,000. Since 1867 the library has grown from 2,000 volumes to 9,000; scientific apparatus has been increased in a yet greater ratio. The School of Mines numbered last year over 100 students. In addition to the School of Mines, the following professional schools are now fully organized in connection with the university, viz.: Normal School, Agricultural and Mechanical College, College of Law, Medical College, and Department of Analytical and Applied Chemistry.

SIXTH ANNUAL REPORT OF THE GEOLOGICAL SURVEY OF INDIANA. By E. T. COX. Indianapolis, 1875. Pp. 287.

IN this volume we have the results of the detailed survey of five counties, viz., Jefferson, Scott, Jackson, Brown, and Morgan, as also of special researches in other parts of the State. In a former number of the MONTHLY we gave the result of one of these special researches, viz., the discovery of a considerable bed of white porcelain clay, in Lawrence County. Another inquiry prosecuted by the State surveyors during the year 1874 had reference to the archæology of Indiana: attention was directed to collecting stone implements and other relics of the mound-builders, and to the mapping of tumuli and walled or fortified prehistoric village-sites. Only a small portion of the State has been as yet examined, with a view to researches of this kind, yet the results attained are highly gratifying. The volume before us gives a detailed description of some very remarkable monuments of the mound-builders. One of these, built on a high bluff which overlooks the Ohio River, consists of two circular piles of stone with neck-like prolongations lying in opposite directions; greatest diameter, twenty-two feet; length, forty feet. The mounds are built of stones piled up regularly and lapped so as to break joints, but without mortar. Another curious monument is an earthwork, circular in shape, six hundred yards in circumference, ten or twelve feet wide, and at present fifteen to twenty inches above the general surface. There is a gap six to eight feet wide in the northeast part of this circular wall. Four or five other mounds are described in the work.

In the chapters devoted to the several counties, the economic geology of each receives due attention. The principal minerals of economic value found in Jackson County are building-stone, brick-clay, and ochre. In Brown County gold is found in the bed or on the bars of all the brooks that flow into Bean Blossom Creek from Indian Creek Ridge. Fine dust and minute scales may be found in the county wherever black sand and small pebbles indicate former currents of ice-water. The metal is of unusual purity, but the total product of gold in the county has not exceeded ten thousand dollars. There are numerous quarries of valuable building-stone in the county. The manganiferous iron-stone of Scott County yields an excellent quality of mill and foundery iron. There are as many as thirteen distinct seams of the ore, ranging from three inches to one foot or more in thickness, in a vertical space of twenty feet. Beyond brick-clay and building-stone, Jefferson County possesses no minerals of any considerable economic importance.

The volume contains a "Synopsis of the Fishes of Indiana," by D. S. Jordan, M. D., and a "Partial List of the Flora of Jefferson County," by John M. Coulter.

SCRIPTURE SPECULATIONS; with an Introduction on the Creation, Stars, Earth, Primitive Man, Judaism, etc. By HALSEY R. STEVENS. Newburg: The Author. For sale by C. P. Somerby, New York. Pp. 419. Price, $2.00.

THIS work may be called a running commentary on the text of the Scriptures. The author has no hesitation in expressing his opinions, but yet he does not transgress the limits of just criticism. He has no prejudices against the "sacred books," but he is unwilling that they should be reverenced without discrimination. "Faith," says he, "is excellent if founded on a noble life. . . We have no intention of setting at naught infinite wisdom or of treating eternal things with irreverence. The manly course for all writers is to say what they think just and true, and leave the event to God. Keeping back truth is a sin."

FIRST BOOK IN ARITHMETIC. Pp. 154. Price, 50 cents. Also, THE COMPLETE ARITHMETIC, ORAL AND WRITTEN. Pp. 498. Price, $1.40. By DANIEL W. FISH, A. M. New York: Ivison, Blakeman, Taylor & Co.

ALGEBRAIC PROBLEMS. By JOSEPH FICKLIN, Ph. D. (same publishers). Pp. 184. Price, $1.50.

THESE books belong to the series known as "Robinson's Shorter Course." In paper, print, and binding, they are very attractive. The "First Book in Arithmetic" abounds in pictures, which are employed not so much for the purpose of embellishment, as in order to make plain to the infant mind the problems and operations set before it. "The

Complete Arithmetic" is designed to fill the place usually occupied by three or more graded text-books. "Algebraic Problems" is intended for the use of teachers. It contains a great variety of problems, by means of which the student's knowledge of the principles of algebra may be tested.

HALF-HOURS WITH INSECTS. By A. S. PACKARD, JR. Parts VI., VII., and VIII. Price per Part, 25 cents. Boston: Estes & Lauriat.

THE numbers of this series cost but a trifle each, and when completed they will make a volume, not only of fascinating interest, but full of valuable practical information. Of the parts before us, VI. is on the "Population of an Apple-Tree," VII. on "Insects of the Field," and VIII. on "Insects of the Forest." The illustrations are numerous and well executed, and the descriptions are admirably clear.

A MANUAL OF METALLURGY. Vol. II. By W. H. GREENWOOD. New York: Putnams. Pp. 371. Price, $1.50.

WE have here a comprehensive account of the usually accepted methods of extracting the useful metals from their ores. The scientific principles involved in each process are clearly set forth, and the processes themselves described with considerable detail, though the author does not descend to the ultimate technical minutiæ. The metals treated of in this volume are copper, lead, zinc, mercury, silver, gold, nickel, cobalt, aluminium. The subject of assaying, although it forms an important branch of metallurgy, is not touched upon, as being too large for the compass of the work. Numerous excellent woodcuts serve to illustrate the text.

NATURE AND CULTURE. By HARVEY RICE. Boston: Lee & Shepard. Pp. 202. Price, $1.50.

THIS book is made up of six unconnected essays, the first, "Nature and her Lessons," being an exposition of current scientific theories of the origin of the universe, and the history of the earth's changes. The author's style is very attractive, and doubtless this essay will tend to suggest many a novel line of thought to the reader previously unacquainted with the current of modern scientific research and speculation. The other subjects treated are: "Woman and her Sphere;" "Education and its Errors;" "America and her Future;" "Life and its Aspirations." The final chapter contains an address delivered by the author on the occasion of the dedication of a "Mission Monument" apparently on the grounds attached to Williams College.

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PUBLICATIONS RECEIVED.

The Border-Lands of Insanity. By A. Wynter, M. D. New York: Putnams. Pp. 321. Price, $2.00.

Weights, Measures, and Money, of All Nations. By F. W. Clarke, S. B. New York: Appletons. Pp. 117. Price, $1.50.

The Mechanic's Friend. By W. E. A. Axon. New York: Van Nostrand. Pp. 348. Price, $1.50.

Report on United States Marine Hospital Service. Pp. 260.

Health Fragments. By G. H. Everett, M. D. New York: Somerby. Pp. 312. Price, $2.00.

Soul Problems. By Joseph E. Peck. New York: Somerby. Pp. 63. Price, 70 cents.

Elements of Meteorology. Part II. By John H. Tice. St. Louis: the Author. Pp. 216. Price, $2.50.

Politics as a Science. By Charles Reemelin. Cincinnati: Clarke & Co. Pp. 186.

The Taxidermist's Manual. By Captain Thomas Brown. New York: Putnams. Pp. 163. Price, $1.25.

Daily Bulletin of the United States Signal Service. 4 vols.

The Mechanical Engineer. An Address by R. H. Thurston. New York: Van Nostrand. Pp. 24.

Water and Water Supply. By W. H. Corfield. New York: Van Nostrand. Pp. 145. Price, 50 cents.

Course to be pursued with an Eye lost through Accident. By J. J. Chisolm, M. D. Pp. 8.

## MISCELLANY.

**United States Board for testing Iron and Steel.**—We have already (in the July number of the MONTHLY) called attention to the researches proposed to be made by the United States Board for testing Iron and Steel, and recur to the subject in order to stimulate those of our readers who may be in possession of facts bearing on the inquiry to communicate with the chairmen of the various committees into which the board has been divided. These committees are fifteen in number. The committee on abrasion and wear, chairman, R. H. Thurston, has to examine and report upon the abrasion and wear of railway wheels, axles, rails, and other materials. Another subject of investigation by this committee is the wear of tools under the various conditions of workshop practice. The committee on armor-plate, chairman, Lieutenant-Colonel Q. A. Gillmore, U. S. A., will make tests of armor-plate, and collect data derived from experiments already made to determine the characteristics of metal suitable for such use. A. L. Holley is chairman of the committee on chemical research, whose duty it is to plan and conduct investigations of the mutual relations of the chemical and mechanical properties of metals. The committee on chains and wire-ropes, whose chairman is Commodore L. A. Beardslee, U. S. N., is charged to determine the character of iron best adapted for chain-cables, the best form and proportions of link, and the qualities of metal used in the manufacture of iron and steel wire-rope. The committee on corrosion of metals, W. Sooy Smith, chairman, is to investigate the subject of corrosion of metals under the conditions of actual use.

The committee on the effects of temperature, chairman, R. A. Thurston, will investigate the effects of variations of temperature upon the strength and other qualities of metals. That on girders and columns will arrange and conduct experiments to determine the laws of resistance of beams, girders, and columns, to change of form and to fracture. Two committees on iron, wrought and cast, chairmen, Commander Beaslee and Lieutenant-Colonel Gillmore, will examine and report on the mechanical and physical properties of wrought and cast-iron. The committee on metallic alloys, chairman, Prof. Thurston, is to make experiments on the characteristics of alloys and to investigate the laws of combination. That on orthogonal simultaneous strains, chairman, W. Sooy Smith, will experiment on such strains with a view to the determination of laws. W. Sooy Smith is also chairman of the committee of physical phenomena, who will investigate the physical phenomena accompanying the distortion and rupture of materials. The committee on reheating and rerolling, chairman, Commodore Beaslee, will observe and experiment on the effects of reworking metals; of hammering as compared with rolling, and of annealing metals. A committee on steels produced by modern processes, A. L. Holley, chairman, will investigate the constitution and characteristics of steels made by the Bessemer, open-hearth, and other modern methods. Finally, the committee on steels for tools, chairman, Chief-Engineer D. Smith, U. S. N., is directed to determine the constitution and characteristics and the special adaptations of steels used for tools. Each of these committees has issued a circular, more particularly defining the researches in which it is engaged; they can be obtained from the secretary of the board, Prof. Thurston, Stevens Technological Institute, Hoboken, New Jersey, or from the respective chairmen.

**Stanley's Expedition.**—Letters have been received by James Gordon Bennett, of this city, from Henry M. Stanley, commander of the expedition fitted out for the exploration of the interior of Africa by the proprietors of the *New York Herald* and the London *Telegraph*. The letters were written at a village called Kagehyi, on the extreme southern shore of Victoria Niyanza. The expedition reached that point on February 27, 1875, after an arduous march of 103 days from the sea-coast. There were in the expedition, as soldiers and carriers, over 300 men, all native Africans except five, the commander and four Englishmen. For the first 175 miles Stanley followed Livingstone's route nearly due west, but, having reached

the western frontier of Ugogo, he quitted the beaten path, and, for the remaining 550 miles, his line of march lay steadily in a northwestern direction. A few days later, the guides who had been hired in Ugogo deserted, and the trail which the expedition had been following was lost in a labyrinth of elephant and rhinoceros tracks. Still continuing his march to the northwest, Mr. Stanley's men, with great difficulty, forced and cut their way through a dense jungle on the third day after the guides had deserted. The following two days' march was very trying to the men, who suffered from hunger and thirst, and a halt was ordered until provisions could be got from Suna, a place distant nearly thirty miles. While waiting, the men had two scanty meals of gruel, which was made in a sheet-iron trunk. At a point 400 miles from the sea, Edward Pocock, one of the four Englishmen, died of typhoid fever. Thirty of the blacks were on the sick list, and six had died at Suna. The most stirring incident of the entire march to Victoria Nyanza was the three-days' battle with the people of the Lewumbu Valley. The savages were soundly whipped, and many of their villages burned. The plunder of the villages supplied the force with provisions for six days. Stanley lost twenty-one men in this little war; and when, three days later, he numbered the expedition, it was found that there remained only 194 men, and the number was still further reduced before he reached the shores of Victoria Nyanza. On his arrival at Kagehyi, he had only 166 native soldiers and carriers, and three white men.

The second letter gives an incomplete account of a reconnoissance of the coast of Victoria Nyanza. This reconnoissance was made in a cedar boat, which had been carried in sections from the sea-coast. Mr. Stanley, in this boat, the Lady Alice, surveyed all the coasts of the lake, sailing over 1,000 miles in fifty-eight days. In the letter which we call the *second*, Mr. Stanley mentions a previous letter which he wrote at Mtesa, on the north shore of the lake, latitude 0° 20′ north, longitude 33° east. There he met Colonel Linant de Bellefonds, of Gordon's staff, and gave him a letter for transmission to England. Strange to say, this letter has not yet reached its destination, while two other letters, one of them of later date, and which were sent *via* Unyanyembe to Zanzibar by caravan, have been received. A map accompanies the "second" letter. This map, being based on actual survey, decides the question, long discussed, whether Victoria Nyanza is one lake or a multitude of lakes. It is seen to be one vast sheet of water, with length and breadth nearly equal, but with its largest diameter lying from northeast to southwest. Its extreme northern limit is in latitude 0° 30′ north, and its extreme southern limit in latitude 2° south. East and west it reaches longitude 34° 30′ east, and 31° 50′ east, respectively. During Stanley's absence from Kagehyi, Frederick Barker, one of his English followers, died there of fever. The newspapers in whose service Mr. Stanley is engaged ought to have attached to his staff a secretary possessed of some little literary tact. Mr. Stanley's own communications are verbose to the last degree: they give no clear idea of the nature of the countries visited; their inhabitants; how the expedition obtained supplies, etc. The two letters already published purport to give the history of about six months, but they are in volume equal to about one-fourth of Cæsar's famous memoirs of the Gallic War, which extended over nine years.

**Putrefaction arrested by Pressure.**—A communication to the Paris Academy of Sciences, by M. Paul Bert, on the "Influence of Air-Pressure on Fermentation," a summary of which appears in the *Academy*, states that a piece of meat placed in oxygen, with a pressure of twenty-three atmospheres, remained from July 26th to August 3d without putrescence or bad odor. It consumed in that time 380 cubic centimetres of the gas. A similar piece, suspended in a bell-glass full of air at the ordinary pressure, acquired a bad smell, consumed all the oxygen, amounting to 1,185 centimetres, and was covered with mould. Another trial was made with oxygen at a pressure of forty-four atmospheres; no oxygen was absorbed between December 19th and January 8th, and no bad odor was exhaled. M. Bert could eat cutlets

preserved in this way for a month, and found them only a little stale in flavor. After being exposed to air at this pressure, allowing an escape so that only normal pressure remained, the meat suffered no damage, provided the bottle was well corked, so that no external germs could enter. Thus it appears that the micro-ferments which cause fermentation can be killed, when they are moist, by a sufficient tension of oxygen. Fermentations of milk and wine are arrested by high pressure, and fruits keep sound. Diastase continues to act as a ferment, and bodies of this description preserve their properties indefinitely if retained under pressure.

**Meeting of the French Association for the Advancement of Science.**—The President of the French Association for the Advancement of Science, M. d'Eichthal, delivered an address at the opening of the Nantes meeting, on the connection between pure science and the various methods employed to satisfy the wants of humanity. The text of this address has not yet come to hand, but we give herewith the summary of it, which is published in *Nature*. It would be almost impossible, he said, to enumerate all the branches of human activity which owe their success to the researches of pure science—hygiene, medicine, surgery, the fine arts, mechanics, industry in all its branches, mining, metallurgy, textile industries, lighting, warming, ventilation, water-supply, etc. He then referred in detail to several examples of the influence which the results of science have had upon progress in the arts, with the motive forces of water, air, and steam, mentioning a multitude of names of men eminent in pure science, from Pascal and Boyle down to Faraday and Sir William Thomson, upon the results of whose researches the great advances which have been made in machinery of all kinds have depended. He then spoke of electricity in connection with the names of Oerstedt, Ampère, Faraday, Becquerel, and Ruhmkorff; passing on to speak, at some length, of the steam-engine in its various forms, of the progress which, by means of scientific research, is being made in its construction and its uses, and of the great services which this powerful application of a scientific discovery renders to man. M. d'Eichthal advocated the establishment of local centres of culture as the best counterpoise to that over-centralization to which France owes so many of its social misfortunes. "In our time," said he, "science, history, and literature, have great wants. Libraries, lecture-halls, laboratories, costly materials, instruments numerous and expensive, are indispensable to pupils for learning, and to teachers for carrying on their researches; it is by putting, on a large scale, these resources at their disposal, that we can attract and fix in our midst men eminent in all branches of human knowledge."

**Thermo-diffusion.**—In the Physical Section, M. Merget stated the results of his researches on the thermo-diffusion of porous and pulverulent bodies in the moist state. A "thermo-diffuser" is any vessel of porous material, filled with an inert powder, into which is plunged a glass or metal tube pierced with holes. On heating this apparatus, after it has been wetted, water-vapor is given off copiously, passing through the porous substance, while dry air passes through the apparatus in the contrary direction, escaping through the tube. If we stop the mouth of the tube, there is produced a pressure amounting to three atmospheres at the temperature of a dull-red heat. If the pulverulent mass or the porous body ceases to be moist, all passage of gas is stopped. These facts the author does not explain, but he shows that De la Rive's explanation cannot be accepted. M. Merget is satisfied that he has here to do with a thermo-dynamic phenomenon. Thermo-diffusion must play an important part in the gaseous exchanges of vegetal life, as the author showed by taking a leaf of *Nelumbium* as a thermo-diffuser. M. Merget also offered some observations on the Respiration of Plants. He said: If under the influence of light, however feeble, we plunge into water containing carbonic acid, an aërial, or, better, an aquatico-aërial leaf, passing the extremity of the petiole into a test-tube, where the pressure will be a little less than that of the atmosphere, then there will form around the stomata of the leaf an atmosphere of carbonic acid, and oxygen will be discharged from the end of the petiole.

The more intense the light, the more rapid the disengagement of oxygen, and under the influence of solar light a single leaf of *Nuphar* has yielded as much as five cubic centimetres of oxygen per minute—corresponding to the fixation of one gramme of carbon in ten hours. But, if we preserve all the other conditions, abstracting only light, the bubbles of carbonic acid at the stomata disappear, the cell fills with water, and ceases to respire. Thus it is in the *gaseous state* that carbonic acid is decomposed by the chlorophyll; and, according to the author, chlorophyll possesses the property of directly breaking up gaseous carbonic acid into its elements, carbon and oxygen.

From all this it follows that the passage of carbonic acid through the stomata is a purely physical phenomenon, not vital—a phenomenon of thermo-diffusion.

**Religion of the Canarians.**—The superstitious practices in use among the primitive Canarians was the subject of a paper read by Señor Chil y Naranjo. On Gran Canaria, he says, the natives believed in an infinite being, Alcorac or Alchoran. Him they worshiped on the summits of mountains, as also in little temples called almogaren. Their priests were women, and were bound by a vow of chastity. The sacred places were also asylums for criminals. The Canarians believed in the existence of an evil spirit, Gabio. On Teneriffe the Guanchos worshiped Achaman, and used to assemble in consecrated places for common prayer. On Palma, the name given to the Supreme Being was Abara. In all the islands homage was rendered to the emblems of fecundity and to the four elements. Their sacrifices were such as would be esteemed most precious by a pastoral people. They attributed will to the sea; it was the sea that gave them rain. In time of drought they scourged the sea, and implored the aid of Heaven with great ceremony.

**Microcephaly.**—Dr. Laennec exhibited a microcephalous idiot, aged fourteen years, of the male sex. This child is entirely unconscious of his own actions, and his intellectual operations are very few in number and very rudimentary. His language consists of two syllables, *oui* and *la*, and he takes an evident pleasure in pronouncing them. He takes no heed in what direction he walks; he would step off a precipice or into a fire. Dr. Laennec called attention to the idiot's hands; the thumbs are atrophied and cannot be opposed to the other fingers. The palms of the hands have the transverse creases, but not the diagonal—the result of the atrophy of the thumbs. Hence the hand resembles that of the chimpanzee. The dentition too is defective. Though fourteen years of age, the child has only twelve teeth.

**The Booted Eagle.**—M. Louis Bureau stated the results of observations on varieties of the booted eagle (*Aquila pennata*), the smallest European bird of the eagle tribe. M. Bureau, having examined a number of broods of the booted eagle, says that all the varieties of this species may be reduced to two chief types, white and black. In pairs, both of the sexes sometimes belong to one type, but they more usually are of different types. In fact M. Bureau has found in the same forest, and at but little distance from one another, two pairs, in one of which the male was black, and the female white, and, in the other, the male white and the female black. As a rule, the young birds are either all black or all white. But in one nest, containing two chicks, the one was white, the other black. From this it follows that these variations of color are not correlated with the age of the bird.

**St. Louis Academy of Science.**—At a recent meeting of the St. Louis Academy of Science, Prof. Riley read a paper on the canker-worm, in which he says that two sorts have hitherto been confounded under this name, that are not only specifically, but he thinks generically, distinct. They present important structural differences in the egg, the larva, the chrysalis, and the moth states; and also differ in the time of their appearance: one species rising from the ground mostly in early spring, the other mostly in the fall. Both attack fruit and shade trees, but, while the spring sort is common and very injurious in the apple-orchards of the Western States, the other is rare there, and most common in the elms of New England. To combat the former,

or spring species, fall ploughing under the trees, which breaks up their fragile cocoons that lie secreted in the soil, and in early spring scraping the trunks of the trees where their eggs are lodged in the crevices of the bark, are recommended. These measures fail with the fall sort, and, in the abstract of the paper now before us, nothing is suggested to take their place.

At the same meeting Prof. Riley also presented a paper giving an account of some recent experiments with the grape phylloxera, undertaken for the purpose of determining when the winged female deposits her eggs. He built a tight gauze house six feet high and four square over a Clinton vine. The house was built so as not to permit even so small an insect as the winged phylloxera to get in or out, and the vine was trimmed so that but few branches and leaves remained to be examined. Into this inclosure he brought an abundance of infested roots, and from these obtained a supply of the winged females, confined where he could watch their ways. The result of these observations is that, as has been surmised, the eggs are often laid in crevices on the surface of the ground, but still more often on the leaves, attached generally by one end amid the natural pubescence of the under surface; and, while heretofore all efforts to artificially hatch the progeny from these eggs have failed, Prof. Riley has this year succeeded in hatching them, and presented a tube filled with living females.

**Condensed Beer.**—A process for condensing beer, recently patented in England, is described as follows in the *English Mechanic*: Beer or stout is taken at any stage of fermentation, though the process is better applied when it is fit for drinking, and evaporated in a vacuum-pan until it becomes a thick, viscous fluid. The alcohol and water of course pass off in vapor, which, in turn, is condensed in a receiver, and the alcohol recovered by redistilling the liquid. This alcohol may be mixed again with the condensed beer. By this process of condensation, the beer is reduced to one-eighth or one-twelfth of its original bulk, and, as the fermentation is suspended by the heat employed, the condensed mixture will keep in any climate for any length of time. The process of reconverting the mixture into beer is also a simple one, consisting merely in adding the bulk of water originally abstracted, and setting up fermentation again by the use of a small quantity of yeast or other ferment. Within forty-eight hours the beer may be drawn from the tap for use, or bottled in the ordinary way; or, without using any ferment, the beer may be bottled, and charged with carbonic-acid gas

**Is Consumption contagious?**—Some experiments and observations recently made, on the transmission of tuberculosis or phthisis from one animal to another, are worthy of note, as indicating one fruitful source of pulmonary disease. Thus it has been found that when an animal with tuberculated lungs is made the yoke-fellow of a perfectly healthy animal, and the two are housed and fed together, so as to inhale one another's breath, the one which at first was sound, before long exhibits the symptoms of tuberculosis. Again, Krebs has produced tuberculosis by giving animals milk from those which were diseased. In addition to rabbits and Guinea-pigs (which animals are very susceptible to the artificial production of the malady), he accidentally induced the disease in a dog by feeding it with the milk of a cow in the last stage of phthisis. As a result of his observations, he asserts that tubercle virus is present in the milk of phthisical cows, whether they are slightly or gravely affected. On vigorous subjects such milk may produce no injurious effects, but the case is likely to be different with children, and those of enfeebled constitution. Similar effects may result from eating the flesh of animals affected with tubercle, and by inoculation with the virus. Thorough cooking of milk and flesh-meat neutralizes their injurious action.

**Continuity of the Guano-Deposits.**—Are guano-deposits of recent formation, or do they date from a geological epoch prior to the present? The latter opinion has been held by many eminent scientific men, among them Humboldt. The observations of Boussingault, however, go to prove the recent origin of these deposits. One fact, cited by Boussingault in support of this theory, is the existence in the guano of the bodies of birds

with their soft parts preserved. These remains have been attentively studied by Barral, who shows that they belong to existing species. One of these birds was identified as a species of cormorant, which is common on the coast of Peru. Then there is a sort of gannet, which frequents all parts of the Pacific; a species of petrel; and finally the penguin. There are also fragments of the bones of mammals belonging to the eared seal. All these species extend very much farther south than the guano islands, and if deposits of guano have not been found in the colder islands of the Pacific Ocean, it is probably because the rainfalls have removed the birds' excrement, which in other localities has accumulated.

**Centennial Display of Mineral Products.**—It is the intention of the Department of the Interior to have at the Centennial Exhibition a collection of the mineral products of the United States. The Smithsonian Institution has been charged with the work of making this collection, and accordingly Prof. Joseph Henry has published a circular, inviting the coöperation of mine-owners, superintendents, engineers, geologists, and all others who are able to contribute to the attainment of the object in view. "Such a collection," says the circular, "formed and arranged with skill and discrimination, is important, for the purpose of presenting a general view of the extent and variety of these productions at the Exhibition, and will constitute a portion of the National Museum, where it will be permanently arranged after the Exhibition." Letters of inquiry, with regard to this collection of minerals, should be addressed to Prof. W. P. Blake, New Haven, Conn.

**Resuscitation of the Drowned.** — The Massachusetts Humane Society has published the following plain directions for saving the lives of persons rescued from drowning after they have become insensible:

1. Lose no time. Carry out these directions on the spot. 2. Remove the froth and mucus from the mouth and nostrils. 3. Hold the body, for a few seconds only, with the head hanging down, so that the water may run out of the lungs and windpipe. 4. Loosen all tight articles of clothing about the neck and chest. 5. See that the tongue is pulled forward if it falls back into the throat. By taking hold of it with a handkerchief, it will not slip. 6. If the breathing has ceased, or nearly so, it must be stimulated by pressure of the chest with the hands, in imitation of the natural breathing, forcibly expelling the air from the lungs, and allowing it to reënter and expand them to the full capacity of the chest. Remember that this is the most important step of all. To do it readily, lay the person on his back, with a cushion, pillow, or some firm substance, under his shoulders; then press with the flat of the hands over the lower part of the breastbone and the upper part of the abdomen, keeping up a regular repetition and relaxation of pressure twenty or thirty times a minute. A pressure of thirty pounds may be applied with safety to a grown person. 7. Rub the limbs with the hands or with dry cloths constantly, to aid the circulation and keep the body warm. 8. As soon as the person can swallow, give a tablespoonful of spirits in hot water, or some warm coffee or tea. 9. Work deliberately. Do not give up too quickly. Success has rewarded the efforts of hours.

**Trout-Culture.**—In a communication to *Forest and Stream*, Mr. M. Goldsmith, one of the Fish Commissioners for Vermont, states the results of an experiment in trout-culture, which, if verified, cannot fail to have a great influence on the development of artificial fish-breeding. Mr. Hale, of the town of Rutland, has for some months fed the trout in his ponds with bread made of Indian-corn. He adds to the meal a little sugar or molasses of the cheapest sort, and it is stated that the trout eat the bread thus prepared with as much avidity as they do chopped liver or other animal food. The fish are in good condition, though they do not grow quite so rapidly, perhaps, as they would on a flesh diet. Their flesh is firm and has a fine flavor. This discovery, adds Mr. Goldsmith, makes trout-culture not only possible in localities where it would not otherwise be practicable, but in all cases more economical. Whether the vegetable diet can be rigidly practised, is a matter for further inquiry. Even if the result should prove that a certain quantity of animal food

is necessary to the most perfect health of the trout, it is still a fact of great value that they can live, and grow, and fatten, on a vegetable diet.

**Changes in the Skin of Fur-bearing Animals.**—The obvious difference between the fur of animals in summer and in winter is found by Dönhoff to be associated with an equally striking difference in the texture and thickness of their skin. Thus, the average weight of an ox-hide in winter is seventy pounds; in summer, fifty-five pounds; the hair in winter weighs about two pounds, and in summer about one pound; leaving fourteen pounds to be accounted for by the proper substance of the skin. These differences are quite as decided in fœtal animals as in adults. Calves born in winter have a longer and thicker coat than those born in summer; moreover, there is a difference of more than a pound in the weight of their skins after the hair has been removed. Similar facts may be observed in the case of goats and sheep. That these differences are not to be ascribed to any corresponding change in the diet and regimen of the parent animals, is proved by the fact that they are equally manifest in the young of individuals kept under cover, and on the same food all the year round.

**Intensity of Solar Radiation.**—In a letter to Ste.-Claire Deville, Soret alludes incidentally to some recent optical observations which show the great intensity of solar radiation. If we look at an ordinary flame through plates of glass colored blue with cobalt, we observe that with a certain thickness of glass the flame presents a purple color, as the glass transmits the extreme red rays, and the highly-refrangible blue and violet rays, while it intercepts the rays of intermediate refrangibility. If the source of light have a high temperature, and therefore emit highly-refrangible rays, the flame appears blue, and it requires a number of superposed plates in order to develop the purple tint. Thus it was found that, at the temperature at which platinum fuses, two plates would give a purple color; at the fusion of iridium three plates were required, and on observing the sun the purple color was not developed even with half a dozen plates.

**Extinction of Animals in Rodriguez.**—Alphonse Milne-Edwards, in a communication to the Paris Academy of Sciences, shows from documentary evidence that the solitaire and the other gigantic birds of the Island of Rodriguez became extinct between 1730 and 1760. Reports addressed to the Compagnie des Indes show that the island was regarded as a sort of provisioning-store, not only for the Isle of France and the Island of Bourbon, but also for the ships frequenting these parts. One object of their visits was the collection of land-tortoises, and efforts were made by the compagnie to put some restrictions on this business. The land-tortoise has long since disappeared from the island. As for the great birds of Rodriguez, owing to their undeveloped wings they were easily captured, while the delicacy of their flesh caused them to be much sought after.

**Terrestrial Radiation.**—Prof. Thiselton Dyer, at a recent meeting of the British Horticultural Society, made the following communication upon the phenomena of terrestrial radiation and its effects on vegetation, basing his remarks upon the observations of Buchan. The effects of radiation, he said, are at the maximum when the air is calm and very dry, and its temperature rather low. If, however, the cold air produced through the influence of terrestrial radiation be allowed to accumulate close to the ground, no small amount of damage may be done by a comparatively light frost. On sloping ground such accumulation of cold air cannot go on, because, cold air being heavier than air which is warmer, as soon as the air in immediate contact with sloping ground is cooled it flows down to a lower level, just as water would do, and its place is taken by the warmer current of air immediately above. In this way a higher night temperature is maintained in situations where the ground slopes down to lower levels, and accordingly such situations should be chosen for those plants which, at any stage of their growth, are peculiarly liable to be injured by frost. If the air be not calm, but a wind—even a slight wind—be blowing, the different layers of air are thereby mixed; and thus the air cooled by contact with the cold ground is not suffered to rest thereon, but is mixed with the air

above it, and the temperature is thus prevented from falling as low as it otherwise would.

**Trapping Wild-Turkeys.**—There is a touch of cynic humor in a peculiar mode of trapping wild-turkeys in Virginia, as described by a writer in *Forest and Stream*. Having discovered one of the familiar haunts of the birds, the trapper digs a trench eighteen inches deep and about as wide, and four or five feet long, with a slope from the outer end deepening to the middle. A pen of fence-rails is now built, the first rail being laid across the middle of the trench; this is the width of the pen, and it has the length of two rails. It is built to the height of eight or ten rails and covered over with the same. Some grain is now scattered around and in the trench, and a large quantity within the pen. The turkeys get on the train of bait leading into the pen, and with heads down, eagerly picking up the grain, they go under the sill-rail in quest of food. Half a dozen or so will perhaps enter in thus, and then they find themselves imprisoned. They go round and round to find an exit, but it never occurs to them to *look down*, and thus they never find the passage through which they entered.

**Rationale of the Welding of Iron.**—The welding of iron and the regelation of water are very ingeniously traced to the same cause by Mr. M. Jordan. Faraday was the first to observe the phenomenon afterward called "regelation." By this term we imply that when two pieces of ice are pressed even very gently together, the temperature being just below zero, they at once become welded to each other. Of this Thompson offers the following explanation: For all bodies which, like water, have the property of diminishing in volume as they liquefy, pressure, which tends to bring the molecules closer together, lowers the temperature of fusion. Consequently, when two pieces of ice are rubbed against each other, fusion takes place between the surfaces in contact, at a temperature below zero. But as soon as the pressure ceases solidification is again produced, and the pieces are welded together. With iron, observes Mr. Jordan, the case is the same. The two pieces to be welded together are brought to a white heat, i. e., more or less *near* to the fusing-point. The repeated blows of the hammer, or the pressure of the rolls, lowers the point of fusion, causing a superficial liquefaction of the parts in contact, and thus welding the masses together; and this because, like water, iron dilates in passing from the liquid to the solid state. "The careful comparative study of these two bodies," adds Mr. Jordan, "even though at first sight apparently so dissimilar, cannot fail to furnish results of great interest to the metallurgist. The work of the puddler is also based upon the same phenomenon as that of welding. When the puddler forms his ball in the furnace, it is done by rolling together or aggregating the crystals of iron as they form in the mass of melted iron and slag. In other words, the semi-fused crystals are welded or regelated together by the mechanical action of the puddler."

**Propagation of Waves in Liquids.**—At a late meeting of the Paris Physical Society, M. Marey exhibited certain apparatus which he has employed in studying the propagation of waves in liquids. His method consists in producing, at a given point in an India-rubber tube filled with water, a sudden compression or dilatation, either by pressing on the walls of the tube, or by means of a piston. Small clips arranged along the tube at equal distances from each other signal the passage of the wave of compression or dilatation to a registering apparatus. In this way M. Marey has found that the velocity of the waves decreases with the size and increases with the elasticity of the walls. The density of the liquid has also some effect, but this is not of sufficient importance to be taken into account in applying this method of observation to physiology.

**Restoration of Faded Writings.**—Very often paper and parchment documents are illegible owing to the ink with which they were written having faded. The *Revue Industrielle* gives a very simple method of restoring to the ink its color. It is as follows: First, wet the paper and then pass over it a brush dipped in a solution of ammonia sulpho-hydrate. The writing quickly reappears, the characters being of a very deep

black color. In parchment this color is permanent, but in paper it is only temporary. Old parchment chronicles in the Nuremberg Museum which have been treated in this way are now as legible as when first they were written, though before the application of the process all color had faded out of the ink. The *rationale* of the process is, that by the action of the ammonia sulpho-hydrate, the iron of the ink is changed into a black sulphuret.

**An Optical Illusion.**—St. Simon, in his famous "Mémoires," describing the personal appearance of the twelfth Duke of Albuquerque, characterizes his hair as "coarse and *green*." The question here arises, Was the duke's hair really of this color, or was St. Simon the victim of an optical illusion? That the latter was in all probability the fact, is shown in a communication made to the Paris Academy of Sciences by the venerable M. Chevreul, "the oldest student in France." On the day when the Duke de St. Simon saw Albuquerque, the latter wore a *bullock's-blood coat* of coarse cloth, with buttons of the same, and his hair hung down on his shoulders. "Now," says Chevreul, "if we take hairs of a certain color, and arrange them on a red ground in parallel lines, making a small ribbon of them, and place beside them exactly similar hairs on a white ground, the former relatively to the latter will appear green. If for white we substitute orange, the hairs on the red ground will assume a bluish tint; if violet, a yellow tint; if green, a ruddy tint; if blue, an orange tint; if violet, a greenish yellow; and, finally, if we substitute black for the white ground, the hairs on the red ground will become whitened. In short, if we look at a broad surface of one simple color, we see it and appreciate it *absolutely*. If we see it in juxtaposition with another color, or, still better, at the centre of a broad surface of another color, we see it *relatively*, and the sensation produced by it will be quite different."

**A Rat in the Telegraph Service.**—A telegraph-inspector in England recently pressed into his service a rat under the following peculiar circumstances: It was necessary to overhaul a cable of wires inclosed in iron tubes. A certain length of the cable had to be taken out of the tube, and the men commenced hauling at one end without having taken the precaution to attach to the other a wire by which it might be drawn back into the tube after inspection and repairs. The question arose, how the cable was to be restored to its proper place; and here the ingenuity of the inspector was manifested. He invoked the aid of a rat-catcher, and, provided with a large rat, a ferret, and a ball of string wound on a Morse paper drum, he repaired to the opening in the tube. The "flush-boxes" were opened, and the rat, with one end of the string attached to his body, was put into the pipe. He scampered away at a racing pace, dragging the twine with him until he reached the middle of the length of pipe, and there stopped. The ferret was then put in, and off went the rat again until he sprang clear out of the next flush-box. One length of the cable was thus safe, and the same operation was commenced with the other; but the rat stopped short a few yards in the pipe and boldly awaited the approach of the ferret. A sharp combat here commenced, and it was feared that one or both of the animals would die in the pipe. But, after sundry violent jerks had been given to the string, the combatants separated; the ferret returned to his master, and the rat, making for the other extremity of the pipe, carried the string right through, and so relieved the inspector from his anxiety.

**Behavior of Metals with Hydrogen.**—From researches carried on conjointly by Messrs. Troost and Hautefeuille, and reported to the French Academy of Sciences, it appears that potassium, sodium, and palladium, combine with hydrogen, while a considerable number of other metals merely dissolve this gas. Iron, nickel, and manganese, offer striking analogies in their behavior with hydrogen at different temperatures. The facility with which they absorb or give off hydrogen gas depends greatly on their physical condition. An ingot of pure nickel gave out in a vacuum, at a red heat, one-sixth of its volume of hydrogen. Pulverulent nickel gave out 100 times its volume, and remained pyrophoric after the

escape of the hydrogen. An ingot of cobalt gave out one-tenth of its volume, electrolytic laminæ of cobalt 35 times their volume, and pyrophoric cobalt powder 100 times. It also remained pyrophoric after the loss of the hydrogen. Soft iron in ingots gave off one-sixth of its volume, and gray cast-iron more than half. Electrolytic laminæ of iron gave off 260 volumes.

**Disproportion of the Sexes in Germany.**—The proportion of males to females in the population of the German Empire appears to be steadily declining. In 1855 the excess of females over males in what is now the German Empire was 348,631, which declined in the following nine years of peace to 313,383 in 1864. At the end of 1866, that is, after the Schleswig-Holstein and Austrian Wars, the excess was 471,885. In December, 1871, the effects of the war with France was shown in an ascertained surplus female population of 755,875. Thus in the seven years, from 1864 to 1871, the excess of females over males in the German population had increased by no less than 14 per cent. Although no inconsiderable portion of this loss to the German male population is due to actual slaughter on the battle-field, it is undoubtedly caused principally by emigration. Even if emigration could now be checked, it would take more than one generation to restore the proportion between the two sexes in Germany to what it was ten years ago.

**Reduction of Obesity.**—As a means of counteracting a tendency to obesity, and for reducing that habit after it has been established, Philbert recommends a mode of treatment somewhat different from that proposed by Banting. He interdicts the use of carbonaceous food as far as possible, and would augment the amount of oxygen. Hence the food must be nitrogenous, varied with a few vegetables containing no starch, and some raw fruit. The temperament, however, must be taken account of; the lymphatic should have a "red" diet—beef, mutton, venison, pheasant, etc.; the sanguine a "white" diet—veal, fowl, oysters, etc. Vegetables not sweet or farinaceous may be taken. Coffee without cream, and tea with little sugar, may be used. Sugar, butter, cheese, potatoes, beans, etc., are forbidden. In addition to these dietetic precepts, Philbert recommends favoring the action of the skin, supporting the walls of the abdomen by the use of a tight roller, and taking exercise freely. As a purgative, intended to promote the success of the treatment, the author reccommends waters containing sulphate of soda.

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## NOTES.

Sir Charles Wheatstone died at Paris, October 21st, at the age of seventy-three. In England, he is reputed to have been the inventor of the electric telegraph, but in this country his claim is disputed, the credit of that momentous invention being assigned to Morse and Henry. By general consent, he is esteemed one of the most eminent of electricians. He also gained distinction by scientific researches in various other directions, especially in acoustics and optics. At the time of his death, Prof. Wheatstone was Vice-President of the London Royal Society, corresponding member of the Académie des Sciences, Knight of the Legion of Honor, etc.

In the article entitled "A Home-made Microscope," published last month, regret was expressed that the objectives of Gundlach, of Berlin, had not been introduced into this country. Since the appearance of the article, we have received a note from Mr. James Colegrove, of Kendallville, Ind., stating that Gundlach, of Berlin, has for the past two years resided in Jersey City, where he continues the manufacture of his objectives

Died, in Jersey City, September 4th, Prof. Samuel D. Tillman, for many years Corresponding Secretary of the American Institute, and editor of its annual "Transactions." He was a native of Utica; graduated from Union College at the age of twenty; studied law, and for some time was engaged in legal practice at Seneca Falls. About twenty years ago he quitted the legal profession and devoted himself to the study of science. He was an active and prominent member of the American Association. He was familiar with almost every department of science, and, in addition, possessed a great fund of general knowledge. He was the author of a treatise on the theory of music, originated a very ingenious chemical nomenclature, and proposed a new theory of atoms. At the time of his death he was in his sixty-third year.

In an ancient mound recently opened near Detroit there were found a number of human skulls, unaccompanied by any other bones. Dr. Dalrymple, who described this

find at the Maryland Academy of Sciences, says that each of the skulls was pierced at its vertex with a hole about an inch in diameter; this was apparently done some time after death.

DR. GUILLAUME-BENJAMIN DUCHENNE, recently deceased, was born at Boulogne-sur-Mer, in 1806; graduated M. D., at Paris, in 1831. He practised medicine for a while in his native town, and in 1842 came to reside in Paris. He was one of the founders of electrotherapy. He studied with eminent success the play of the facial muscles in the expression of the passions, and his observations and experiments were of great service to Mr. Darwin in the composition of his work on the "Expression of the Emotions." Not to mention his numerous contributions to medical journals, he was the author of several published works, among them a "Treatise on Localized Electrization;" "Researches on the Muscles of the Feet;" "Mechanism of Human Physiology;" "Anatomy of the Nervous System;" "Physiology of Movement," etc.

ON comparing the statistics of the German universities for the summer semester of 1874 with those of the same semester of 1875, the *Allgemeine Zeitung* finds a decrease in the number of medical students; it has fallen from 6,190 to 6,039. One of the causes of this is the fact that now Jewish students devote themselves, in great numbers, to the study of jurisprudence. Until lately, the legal career could hardly be said to be open to Jews in Germany, and hence a great number of them studied medicine.

THE California Peat Company are manufacturing peat-fuel at Roberts's Landing, San Joaquin County, at the rate of from fifty to one hundred tons per day. A recent trial of the product in the furnace of a steam-boiler is said, by the *Scientific and Mining Press*, to have been thoroughly satisfactory in its results.

THE authorities of Tufts College have lengthened their philosophical course to four years, at the same time giving the student greater freedom in the choice of studies.

ACCORDING to the *American Railway Times*, the first suspension-bridge was constructed by James Finley over Jacob's Creek, on the turnpike between Uniontown and Greensburg, Pennsylvania, in 1796.

THE first shipments of tin from Tasmania have arrived in England. This tin is pronounced by the *Mining Journal* to be of excellent quality, soft and of very good color. It is free from even a trace of wolfram, so often found in combination with tin.

THE two-hundredth anniversary of Antony van Leeuwenhoek's discovery of infusoria was celebrated on September 8th at Delft, his birthplace. All the natural history associations of Holland were represented on the occasion, and a fund was established for a Leeuwenhoek gold-medal, worth six hundred marks, to be awarded to distinguished microscopists. The first recipient of this medal was Prof. Ehrenberg, of Berlin, the oldest microscopist of Europe, and Leeuwenhoek's legitimate successor.

A TRIAL-TRIP was recently made on a Scotch railway with a Scott-Moncrieff tramway-car, worked by compressed air. The vehicle resembles a common railway-car, but is a little higher, the reservoir of air being on the roof. The initial pressure was two hundred pounds, and the speed attained ten miles per hour. The car was fully under control; the speed could be increased or reduced at pleasure, and the operations of starting, stopping, and reversing, were readily performed. The estimated cost of the power is three half-pence per mile, as against seven pence per mile for horse-power.

THE cells in a large mushroom, weighing four and a half pounds, were found by Worthington G. Smith to number 106,596,000,000,000. Each of these is furnished with a coat or cell-wall, and contains within itself protoplasm, water, and other materials. These cells are so extremely light that in one species of fungus it takes 1,624,320,000,000 to weigh an ounce troy.

THE British Association this year makes grants of money amounting to nearly £1,500 in aid of scientific research. For the prosecution of researches on "British Rainfall," the Association voted £100, and a like sum respectively for the exploration of Settle Cave and Kent's Cavern, for a record of the progress of zoölogy, and an examination of the physical characters of the inhabitants of the British Isles. The sum of £75 was voted in support of Dr. Dohrn's zoölogical station at Naples, and £200 for completing and setting up in London Sir W. Thomson's tide-calculating machine. The number of beneficiaries is in all twenty-seven.

IT is proposed to hold, in 1877, at the Palais de l'Industrie, Paris, an exposition of all the applications of electricity to art, science, and household use. The enterprise is zealously patronized by men of high distinction in the world of science and of industry. The necessary funds have been guaranteed. The committee in charge have their temporary headquarters at No. 86 Rue de la Victoire, Paris.

SIR CHARLES WHEATSTONE.